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TABLE OF CONTENTS.


| LEADING ARTICLES: | Page. |
|---|---|
| The New Stone-Crushing Plant of the Tomkins Cove Stone Co., Tomkins Cove, N. Y. (illustrated) | 20 |
| Recent Engine-Room Developments in the U. S. Navy | 35 |
| A Revolving Steam Shovel for Sewer Trench Digging (illustrated) | 37 |
| The Flow of Water Over Dams (illustrated); Gardner S. Williams, M. Am. Soc. C. E. | 38 |
| Recent Waste-Detection and Meter Work in the New York City Water Department; Edward W. Bemis | 39 |
| Test of Rivet Steel for Gripping Power (illustrated) | 41 |
| A Land Drainage Project Near Louisville, Ky. (illustrated) | 42 |
| Converting a 56-Year-Old Steam Engine for Triple Expansion (illustrated) | 43 |
| The Report of the Citizens' Committee on the New York Rapid Transit Problem | 43 |
| An Unusual Case of Bridge Erection by the Cantilever Method (illustrated) | 46 |
| Sidewalk Paving Slabs of Destructor Clinker Concrete at Nottingham, England | 46 |
| Rebuilding the La Salle St. Tunnel Under the Chicago River (illustrated) | 52 |
| Improvements in Machinery for Handling Earth and Rock as a Result of Experience at Panama | 56 |
| A White-Print Process and Continuous Printing Machine (illustrated) | 57 |
| Laying Wood Paving With Cement-Grout Cushion Along Street Car Tracks | 57 |
| A New Type of Mill for Fine Grinding (illustrated) | 58 |

| | Page. |
|---|---|
| EDITORIAL | 47 |
| Docking the Record-Breaking Steamships in New York Harbor—Formulas for the Discharge of Water over Weirs—A Steam Engine with a History—Col. Sellers Outdone—A Unique Membership List of an Engineering Society. | |
| Water Waste and the General Inefficiency of the Water Department of New York City | 48 |
| Reducing the Cost of Broken Stone | 48 |
| LETTERS TO THE EDITOR | 49 |
| The Strength of Old Timber: An Instance of Cracking After Long Service; Wm. P. Snow; W. R. Robinson—Depositing Concrete by Gravity in Chutes; Floyd L. Burr—Economical Device to Take the Place of Cast or Forged Angle Washers (illustrated); F. R. Steuart—Cracks in Concrete Building Under Test No Sign of Poor Construction; Arthur R. Lord—The Ownership of Removed Material; Ernest McCullough—The Imhoff Sewage Tank: A Disclaimer; Rudolph Hering—Clay Pressures and Steel Cofferdams (Illustrated); J. W. Pearl—The Design of Cofferdams for Deep Water; Charles H. Higgins—Mistakes of an Unsuccessful Engineer; H. B. H.—An Easily Understood Planimeter (illustrated); S. C. Zuckerman—Hardpan; C. M. Lawrence—Notes and Queries. | |
| ENGINEERING NEWS OF THE WEEK | 59 |
| PERSONALS | 60 |
| ENGINEERING SOCIETIES | 60 |


## The New Stone Crushing Plant of the Tomkins Cove Stone Co., Tomkins Cove, N. Y.

The enormous increase in the use of concrete within the past few years, together with the activity everywhere noticed in the building and rebuilding of good macadam roads, has added considerably to the demand for a good product of crushed stone, particularly in the vicinity of large cities where there is a great quantity of both concrete and road work. For the market adjacent to New York City, the limestone formations on either side of the Hudson River have for many years abundantly furnished a quantity of good crushed stone, and all along the Hudson will be found plants where stone is quarried and reduced to small size. However, it is only within recent years that the increased demand for the stone has forced the owners of these plants to install equipment which can most economically produce the material.

One of the oldest of the stone quarries producing crushed stone in the vicinity of New York City is that owned by the Tomkins Cove Stone Co., on the west bank of the Hudson River some 35 miles above the City of New York. This plant has been in operation by the present owners for some 50 years, and up to the past year had a capacity of about 2,400 cu. yds. in a working day of ten hours. This output was not considered sufficient by the owners, and there has been installed an entirely new plant from quarry to dumping bin with a capacity of from 6,000 to 8,000 yds. in the same working day of ten hours. The new plant is entirely different from the old and of so modern a design as to warrant its description here. Before entering into a description of the new equipment, it would be well to outline briefly the old method of working, which, it is expected, will be abandoned next Spring when the new plant is fully tested out.

As shown on the plan in Fig. 2 the quarry of the company is located immediately alongside of the west shore of the Hudson River, just inside the tracks of the West Shore R. R., so that opportunity is afforded for loading either on cars or on barges in the river. The deposit of stone is a kind of silicious limestone which outcrops on the banks of the Hudson at this point. It runs, when crushed, about 2,500 lbs. per cu. yd. An average analysis from the quarry is as follows:

| | |
|---|---|
| CaO | 26.34% |
| MgO | 16.74 |
| $CO_2$ | 34.10 |
| $Al_2O_3$ | 4.13 |
| $Fe_2O_3$ | 1.05 |
| $SiO_2$ | 12.60 |

The old quarry workings were located in the foreground of the view shown in Fig. 1. The stone was drilled at the quarry face with the ordinary compressed air drills in 20-ft. benches, holes being placed about 6 ft. centers and blasted down. It was then sledged, plug drilled and reblasted until it was of such a size as could be loaded by hand into the small cars, each containing about 2 yds. Some of these cars are shown in the foreground of the view. These

FIG. 1. VIEW LOOKING SOUTH OVER THE QUARRY AND PLANT OF THE TOMKINS COVE STONE CO., TOMKINS COVE, N. Y.
(Old Quarry in two levels in middle foreground, with gravity car system of old plant. New quarry face at right background and new plant in middle background.)

were pushed by hand to the foot of an incline, where an endless chain with grab-hooks carried them to the top to be dumped into a jaw crusher. The product from the crusher was carried by a belt conveyor to a series of rotary screens, the over-sizes from which were recrushed by jaw crushers of the same size as the primary crushers and again screened and delivered into bins. Under these bins was a track carrying small cars of 1 cu. yd. capacity which were loaded by chutes from the pins and put on an elevator which raised them 20 ft. above the tracks of the West Shore R. R. From there they ran by gravity to a point over the railroad tracks or to the docks, where they were dumped into a chute and delivered direct into barges. This plant was in duplicate, each part with a capacity of 1,200 cu. yds. The loading capacity was about an 800-ton barge in six hours.

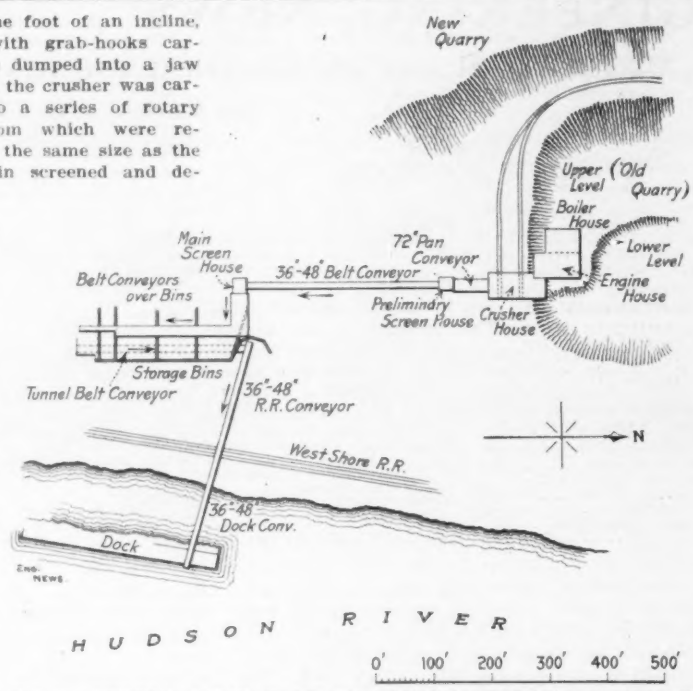



FIG. 2. GENERAL LAYOUT OF NEW STONE CRUSHING PLANT AT TOMKINS COVE.

It is stated by the company that this plant was very successful in many ways, particularly on account of many ingenious adaptations of the gravity principle of carrying the trains. But it had two fundamental difficulties; first, the labor charges were very heavy, and, second, the breaking up of the quarry stone into sizes small enough to enter the jaw crushers added a considerable expense which ought to have been avoided. The labor troubles have been growing constantly on the management from year to year, because it has been very difficult to get satisfactory labor for the period during which the plant works, about nine months. The management, therefore, about two years ago started to investigate new methods of operation, and finally decided upon the one which is described here.

This new plant was completed in November, 1910, was operated only experimentally during the past Fall and will be put into full service at the opening of the season next Spring. It has for its fundamental unit a series of crusher rolls, of the type designed by Mr. T. A. Edison, similar to those installed in the cement mill of the Edison Portland Cement Co. at Stewartsville, N. Y., described in Engineering News, Dec. 24, 1903, p. 555, and a very complete system of belt conveyors, designed by the Stephens-Adamson Mfg. Co., Aurora, Ill. The two difficulties named above in the old plant are avoided because the rock is taken direct from the quarry in large sizes to be dumped into the preliminary crusher, and because, also, the system of transfer is so complete that the labor cost is reduced to a minimum.

Fig. 2 is a general lay-out of the new plant. The stone is quarried at the upper level at the west end of the property at the point marked "New Quarry" in Fig. 2, the location being shown at the far right of the view in Fig. 1. Churn drills work along at the top of the quarry face in a succession of 6-in. holes, and the whole side is blown down in one blast to the track level on an even grade with the main floor of the crusher house. The stone is picked up by these trains and carried into the crusher-house and dumped through the various crusher rolls (to be described hereafter), coming out into a large pan conveyor which lifts it through a preliminary screening onto a belt conveyor, which, in turn, lifts it to the main screen-house. Through the main screen-house the assorted stone is dropped and conveyed by belt conveyors into the various bins. Under these bins runs a tunnel equipped with a belt conveyor on to which any required sized stone may be dumped and carried to the railroad conveyor, which extends out over the railroad and on to the unloading docks. The general train of the stone in its progress from the quarry to the dock may be followed on Figs. 2-3, as noted above.

QUARRY WORKING.—The quarry is worked with churn drills of the type manufactured by the Keystone Driller Co., of Beaver Falls, Pa. The face of the quarry varies from 40 ft. to 140 ft. in height and is of clear stone with very little stripping on top. Holes are bored from the top of this face for the full depth at about 20 ft. intervals and when the whole length of face has been covered the holes are filled with powder and the whole face blown down onto the main level of the crusher-house, there to be picked up by steam shovels and loaded into the cars which carry it to the crusher-house. On account of variation in conditions of blasting and of the strata in the stone it is not possible to give exact data on the amount of powder required to throw down the stone or the cost of quarrying, but it has been found that an average of 3½ ft. per hour of 6-in. hole can be made by the steam-driven drill working on the top of the quarry. When the plant shut down this winter there were two drills, each boring 6-in. holes, and each driven by steam from its own boiler in use, one on the old and one on the new quarry face. To load the broken stone on the cars there were two 95-ton steam shovels employed. The stone that is thrown down is of all sizes, running up to 20 tons in weight and from 8 to 10 ft. in extreme diameter. It is all taken by the cars and dumped without further reduction into the primary rolls in the crusher plant.

The cars which take the quarry stone are shown in Fig. 5. They are of all steel construction, of standard gage and equipped with automatic couplers and hand brakes. Each car carries a steel skip (Fig. 6), 7 × 9 × 4 ft. in size, into which the stone is dumped and which are tipped into the crusher rolls by a special device described below. For the present equipment 40 cars are provided, but more are to be used in the near future. These cars are drawn by 37-ton, saddle-tank locomotives, designed to handle 15 to 20 loaded cars. At present there are three of these locomotives.

### Crusher Plant.

The crusher plant is built into an opening cut into the solid wall of the quarry. As shown in Fig. 4, this opening is about 50 ft. wide and 64 ft. deep at the quarry face, with a level floor at the bottom for a distance of 60 ft. back from that face at which point the slope wall parallels the pan conveyor up to the ground surface. The excavation was made by the regular quarry methods and a layer of concrete then placed about 10 ft. in thickness over the entire interior. All of the machinery of the crusher rolls is carried on cross beams of structural steel which are embedded at their ends in the concrete side walls for support. The main floor level is on grade with the outside car tracks and the upper set of rolls is arranged so that it is just below this level. For protection against weather and to allow room for the upper works of the rolls there is a steel skeleton building covered with corrugated iron, and with reinforced-concrete floors.

There are three sets of rolls, each consisting

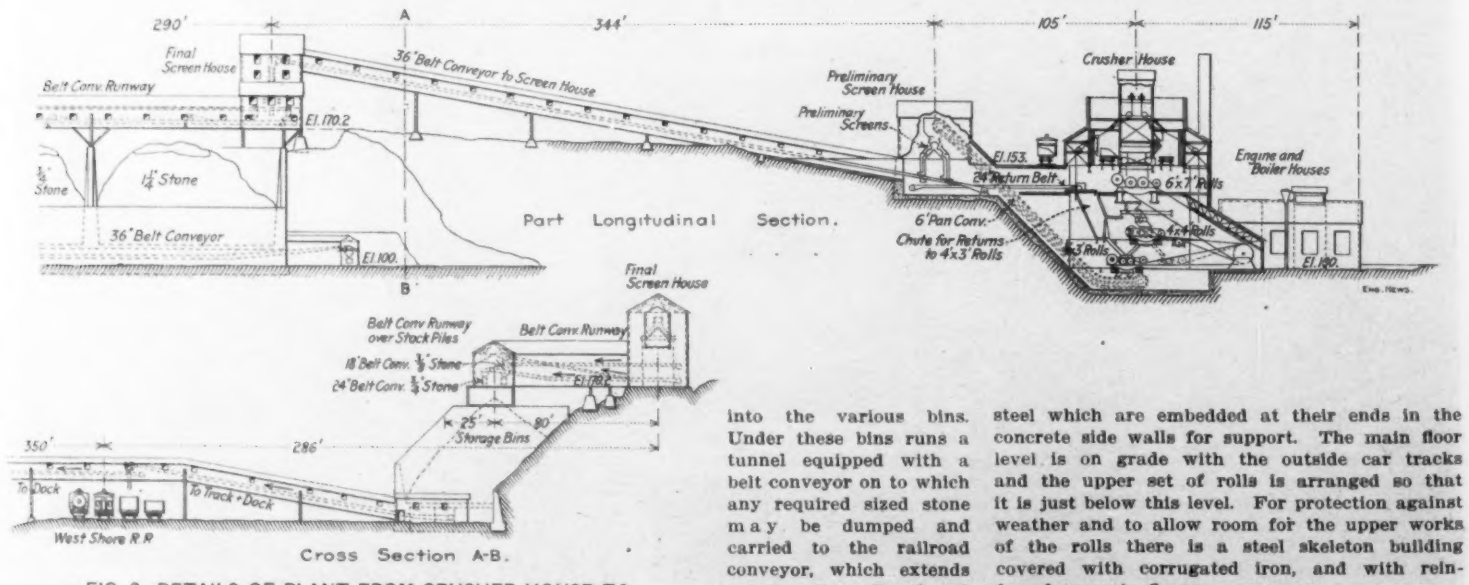



FIG. 3. DETAILS OF PLANT FROM CRUSHER HOUSE TO UNLOADING STAGE.

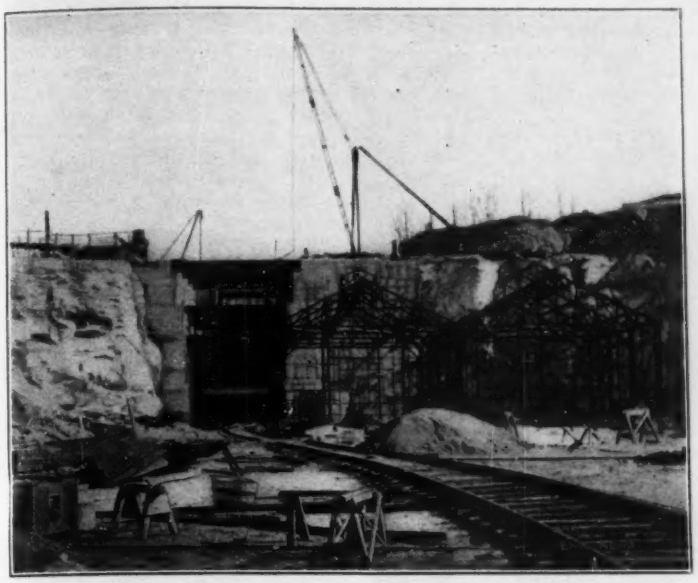


FIG. 4. VIEW OF CRUSHER HOUSE DURING CONSTRUCTION SHOWING CUT IN QUARRY FACE, CONCRETE LINING AND CROSS GIRDERS.

(Framework of engine-house at right.)

of massive steel rollers, turning on parallel axles so that their peripheries are of a given distance apart, just sufficient to pass the stone of the required size, graded down from a 7-in. opening at the top roll to a 2-in. opening at the bottom. The hopper over the top roll is accessible from either side and two lines of track are provided so that the loaded stone cars may be led to the rolls along either side of the hopper. When a train of loaded cars is brought into the crusher building, the locomotive spots each car in front of the dumping platform, to be there dumped by the operation of the tipping device shown in Figs. 7-8.

This device consists of a hook, operated by the tipping hoist, and engaging the tail of the skip on the car. As this lifts, operated by electrical drive from the platform above the hopper, the skip raises from the car and its front end slides forward on the skip table until it engages lugs just over the feed roll in the hopper above the "giant rolls." The hoist continues to raise the rear end of the skip and the load is dumped into the hopper. The feed roll is used only to manipulate large stone and to help empty the skip of its entire load. A counterweight returns the skip to its original position on the car.

The hoist that operates the tipper is electrically driven by a 45-HP. motor giving a rope speed of 45 ft. per min.

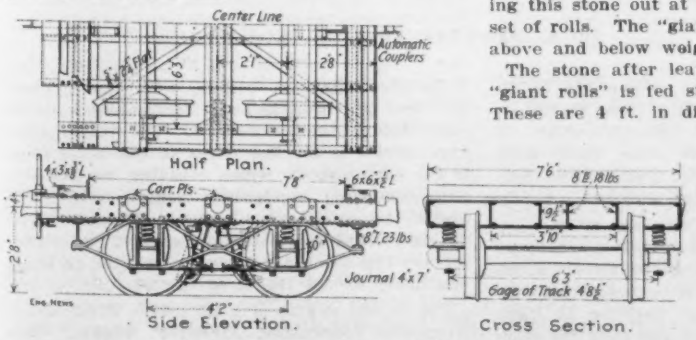



FIG. 5. DETAILS OF STONE CAR.

CRUSHING ROLLS.—The crushing rolls used in the plant are of the familiar Edison type similar to those described in Engineering News, Dec. 24, 1903, p. 556. There are three sets of rolls at the Tomkins Cove plant disposed as shown in Figs. 7-8. The top set, or "giant rolls," consist of two solid rolls 6 ft. in diameter and 7 ft. long, each weighing 48 tons and revolving at 180 r. p. m. The surface of each roll is fitted with knobs, as shown in Fig. 9, and on one roll there are two lines of knobs, each line placed diametrically opposite the other, which stick out some 3 ins. from the rest of the knobs. In action the large stones are tipped down into the plate hoppers and the longer knobs batter them against these plates in the rapid revolution of the rolls until the stone is broken down into such size that it comes inside the angle of grip of the small size knobs, when it is drawn through the rolls in a crushed state. These larger knobs are called "slugger knobs" and it is to them that the first step in the crushing is due. The "giant rolls" are capable of taking a stone 20 tons in weight and will reduce it to a 7-in. size in from 10 to 20 secs.

The upper rolls are entirely surrounded by a hopper of heavy cast steel 4 ins. thick, backed by ribs projecting some 15 ins. farther. These plates extend above the top of the rolls for some feet and form the hopper into which the stones are dumped.

As these rolls crush stone at the rate of 3,000 tons per hour and only operate at intervals, it is necessary to distribute this regularly to the secondary rolls, therefore there is a steel hopper under the "giant rolls" which will contain 30 tons of stone and a double feed roll for feeding this stone out at a uniform rate to the next set of rolls. The "giant rolls" with their hoppers above and below weigh approximately 330 tons.

The stone after leaving the hopper under the "giant rolls" is fed steadily to the second rolls. These are 4 ft. in diameter by 4 ft. long, and reduce the stone to about 4-in. sizes. From here it falls by gravity to the final rolls (Fig. 10), which are 4 ft. in diameter by 3 ft. wide. Both of these sets of rolls revolve at 250 r. p. m., and have a capacity of 1,200 tons per hour. After leaving the final rolls the stone is 2 ins. and less in size.

Provision has been made for installing an additional 4 × 3-ft. roll to work in parallel with the present one, but it seems now that this would never be necessary, as the one roll has ample capacity.

All of the rolls are driven by belts from the main line shaft, and are oiled by a gravity oiling system, by which a large supply of oil is fed through the bearings and drained into a tank in the bottom of the crusher plant, and from here it is filtered and pumped back to the tank above the rolls.

### Conveyors.

As shown on Figs. 7-8, the stone on leaving the final rolls drop into a pan conveyor. This conveyor is supposed to be the largest one of its type ever built. It has a series of 118 steel pans each 72 ins. wide, carried on a steel-bar roller chain with 30-in. pitch and 10-in. flange-rollers, with self lubricating graphite bushings. The shafts are 138 ft. c. to c. and the total length of the conveyor is 200 ft. At the designed speed of 85 ft. per min. this conveyor can carry 1,000 tons of stone per hour. A view of the carrier on the incline out of the crusher-house toward the preliminary screens is shown in Fig. 11.

In addition to this pan conveyor there are in the plant 11 other belt conveyors, as follows: one 36-in. wide, 221 ft. c. to c. shafts (dock conveyor); one 36-in. wide, 177 ft. c. to c. shafts (storage bins to railroad); one 36-in. wide, 287 ft. c. to c. shafts (under storage bins); one 18-in. wide, 291 ft. c. to c. shafts (in storage gallery above bins); one 30-in. wide, 160 ft. c. to c. shafts (in storage gallery above bins); one 24-in. wide, 221 ft. c. to c. shafts (in storage gallery above bins); one 18-in. wide, 87 ft. c. to c. shafts (from screen house); one 24-in. wide, 93 ft. c. to c. shafts (from screen house); one 30-in. wide, 84 ft. c. to c. shafts (from screen house); one 36-in. wide, 371 ft. 6 ins. c. to c. shafts (preliminary to final screen), and one 30-in. wide, 87 ft. c. to c. shafts (preliminary screen back to crusher).

All of the 36-in. conveyors are equipped with adjustable carrying rolls, allowing for an increased width to 48 ins. in case of future enlargement of plant. The positions of each conveyor in the plant is described below in its proper relation to the process of crushing and delivery.

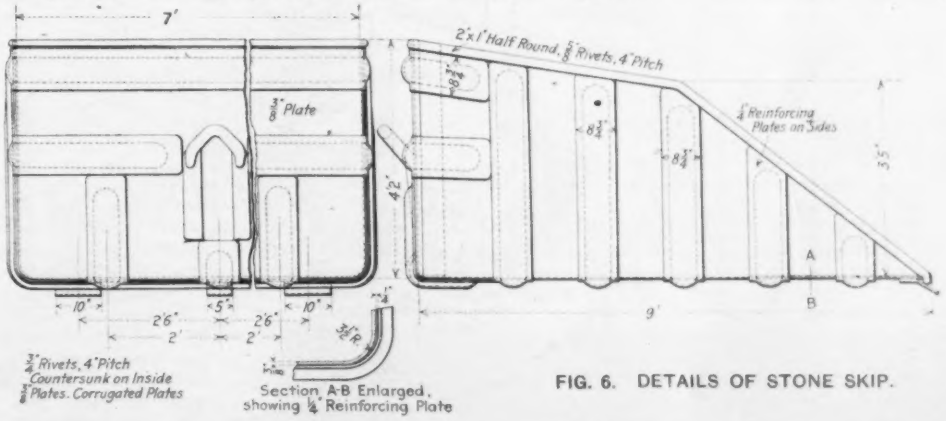



FIG. 6. DETAILS OF STONE SKIP.

### Screens.

The stone is delivered from the large pan conveyor to the preliminary screen, at the top of the conveyor incline, which rejects all stone over 2 ins. in size and casts it back through the chute shown on Fig. 7 to pass again through the final rolls. Thus no stone above 2 ins. can leave the crusher-house. All stone below that size drops through the preliminary screen into a 36-in. belt conveyor which carries it up to the final screen house, where the separation is made into various sizes.

Both the preliminary and final screens are of the Edison patented type, a stationary bank of inclined screens over which the stone falls and separates by gravity. Fig. 13 shows the details of the main screen; the preliminary screens are similar except that the latter are only in two banks, the lower sections shown on the main screens being omitted.

The main screen, about 16 ft. square in plan, is of structural steel skeleton construction and is enclosed in a house covered with corrugated iron. The details of the screen proper are shown in Fig. 13. The stone enters at the top, on the 36-in. belt conveyor, in all sizes up to 2 ins. and is tumbled over the series of steps shown at the cross-section on the right of Fig. 13. These steps have treads of sheet steel but no risers, so that the stone as it drops over them fall through the openings and is distributed uniformly over

the entire half of the screens, the steps on the other side distributing in a similar manner over the other half of the screen. The stone then falls on the horizontally placed solid plates and thence falls over the bank of three inclined screens which pass all stone under 1¼ ins., leaving the stone between 1¼ ins. and 2 ins. to slide into the 24-in. belt conveyors on either side of the structure.

All stone below 1¼ ins. then drops on the inclined solid "wear plates" and slides down to the three banks of inclined screens which pass all material of ⅝-in. and below onto another solid metal "wear plate" to the lowest 18-in. belt conveyors on either side. The material which will not pass these screens drops onto the middle 24-in. belt conveyor. There are thus three separations leaving the screen house, the largest between 2 and 1¼ ins., the next between 1¼ and ⅝ ins. and the smallest below ⅝-in.

Some little time was required to adjust the screens to that angle of inclination which developed the maximum speed of passage of the stone, but once that angle was determined the behavior of the screens is said to be admirable. The principal claims in their favor is that there are no movable parts to wear out or to require attention, and that the stone in no case hits the screen direct but is diverted by first falling on solid plates, which of course wear much more slowly than do the perforated screens.

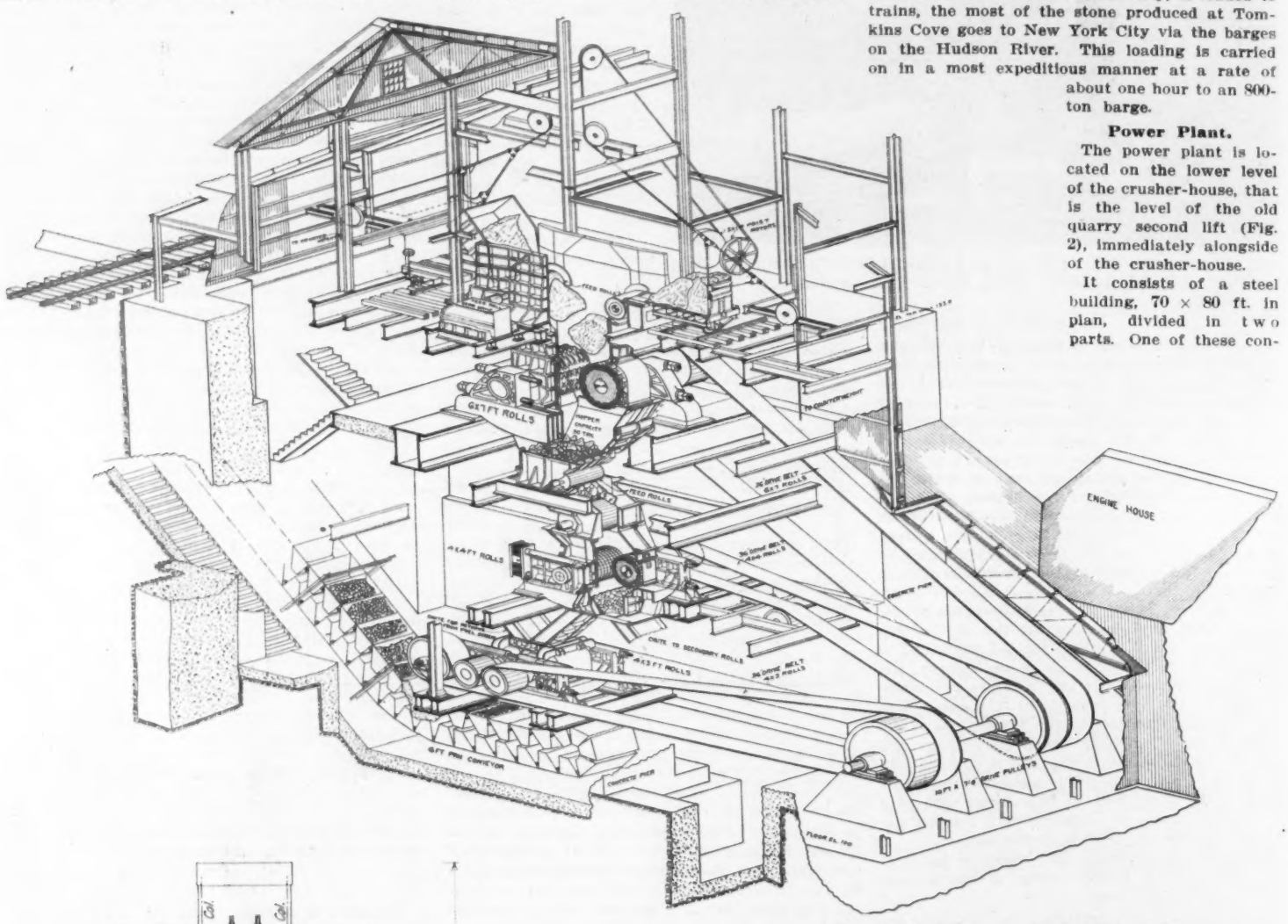



FIG 8. ISOMETRIC VIEW OF CRUSHER HOUSE.

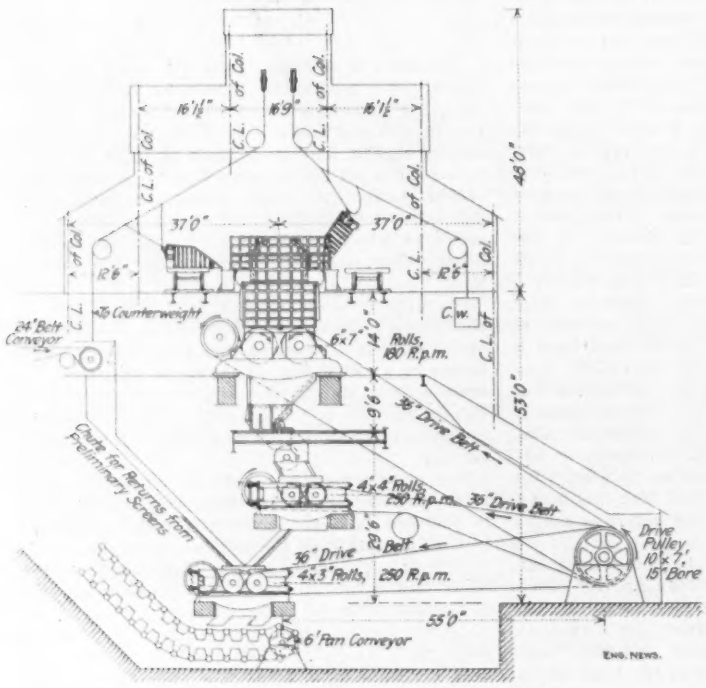



FIG. 7. SIDE ELEVATION OF CRUSHER HOUSE.

### Storage Bins.

The belt conveyors leaving the screen house deliver to three other conveyors running at right angles and over the storage bins. These last conveyors have trippers, which dump the stone into the bins, these trippers being so arranged that any particular bin can be filled with any size stone desired.

There are four bins now built at the plant, formed by building a high retaining wall of reinforced concrete some 50 ft. from the slope of the hill and running from this wall to the hill five connecting walls, thus making four bins each capable of holding 5,000 cu. yds. of stone.

Running under the bins parallel to the overhead conveyors is a concrete tunnel in which there is a 36-in. belt conveyor. From gates in the bottom of each bin, this conveyor can be fed with any size stone desired, which can then be carried to a cross conveyor running out to an overhead dump above the railway track (Figs. 3, 12) or farther out onto the dock, where the barges are loaded directly from a swinging chute. While some of the stone, especially for markets other than New York City, is loaded to trains, the most of the stone produced at Tomkins Cove goes to New York City via the barges on the Hudson River. This loading is carried on in a most expeditious manner at a rate of about one hour to an 800-ton barge.

### Power Plant.

The power plant is located on the lower level of the crusher-house, that is the level of the old quarry second lift (Fig. 2), immediately alongside of the crusher-house.

It consists of a steel building, 70 × 80 ft. in plan, divided in two parts. One of these contains three 300-HP. boilers, with feed pumps, etc., and provision is made for adding more at some future date, if desired. The steam pressure carried is 150 lbs. Next to the boiler room is the engine room, which contains one 600-HP. cross-compound condensing engine, direct-connected to a 550-volt, 3-phase, 25-cycle alternating-current generator, which delivers power for moving all the conveyors and, in fact, all machinery except the three sets of rolls.

The second engine is a 22 × 44 × 42-in. cross-compound condensing, 1,000-HP. engine. This engine is direct-connected to a 15-in. line shaft on which the pulleys are located which drive all the crushing rolls.

On account of the water being salty, a surface condenser was installed, which takes the exhausted steam from both engines and, after being condensed, it is pumped back to the boilers for feed water. The condensing water is pumped from the river by a centrifugal pump through a 10-in. pipe about 800 ft. long, and the discharge water returns by gravity to the river. The pump is driven by a 35-HP. motor. When the old plant is discarded it is expected to make a fresh-water reservoir of the old quarry shown in the

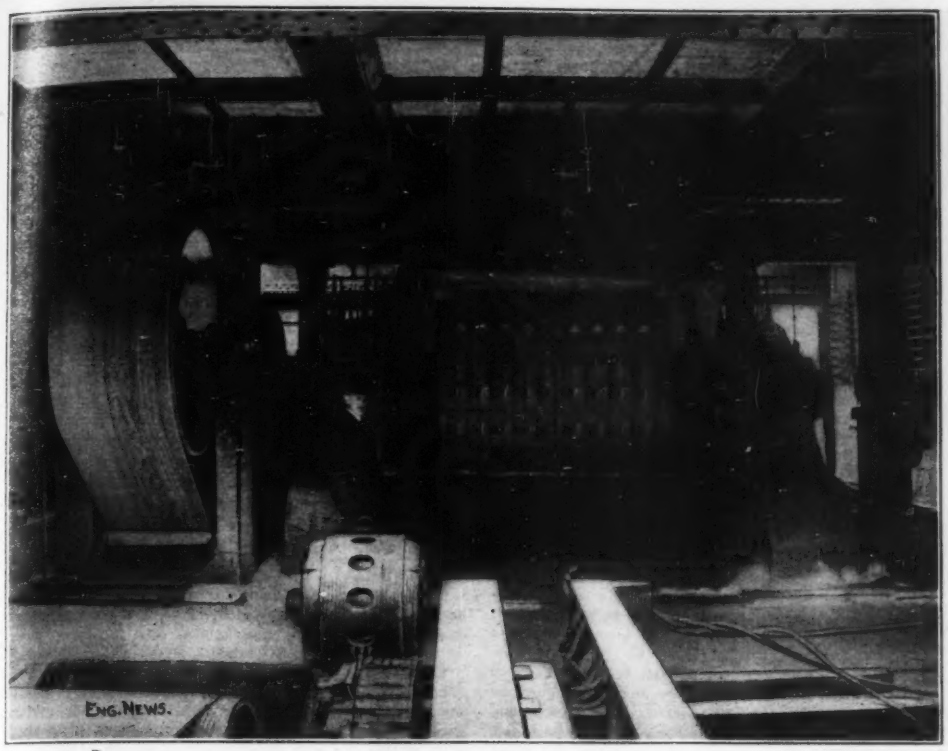



FIG. 9. VIEW OF GIANT ROLLS IN CRUSHER HOUSE.

foreground of Fig. 1, and to use this water for the plant.

**Engineering.**

The plant was designed by Mr. W. H. Mason, of the Edison Crushing Roll Co., Stewartsville, N. J., and was erected under its charge and under the general supervision of the Tomkins Cove Stone Co., with Mr. P. K. Yates, M. Am. Soc. C. E., as Engineer. The structural steel work was furnished by the Snare & Triest Co., New York, and the conveyors and screens by the Stephens-Adamson Mfg. Co., Aurora, Ill. The engines and generators were furnished by the Allis-Chalmers Co., Milwaukee, Wis.

## Recent Engine-Room Developments in the U. S. Navy.

The last few years having brought numerous innovations in the engine-rooms of naval vessels, it is natural that the engineering departments of the navies have been kept busy in working out the inevitable developments. Rear-Admiral H. I. Cone, Engineer-in-Chief of the U. S. Navy, recently gave an official review of what has been and is being done in this direction by our naval engineering department, in a lecture delivered before the U. S. Naval War College on Aug. 10, 1910, and printed in the "Journal of the American Society of Naval Engineers," for November. While his statements are put in succinct technical language, perhaps for that reason they make unusually interesting reading.

Beginning with the noted competitive runs of the three cruisers "Birmingham," "Chester," and "Salem," he deals with the important question of engines or turbines, and then considers the two equally important matters of oil fuel (for use under boilers) and internal-combustion engines using producer gas. The now active subject of oil engines is not mentioned, but its connection with the two preceding matters will be obvious. What Mr. Cone has to say about indirect driving of ships using electric motors, brings out the fact that this novel proposal has good chances for being tried out in practice shortly. Other valuable statements are given, among them the remark that a large decrease in coal consumption has been achieved by the battleship fleet through studied attention to proper firing.

**Steam Turbines vs. Reciprocating Engines.**

Admiral Cone's lecture began with a short statement of the results of competitive trials of the three scout cruisers "Birmingham," "Salem" and "Chester," equipped with reciprocating engines, Curtis turbines and Parsons turbines, respectively. This same ground was covered in our issue of Sept. 1, 1910.* The trials showed the "Birmingham" to consume the least steam, at speeds up to about 20 knots, and to have a very large advantage at cruising speeds, 10 to 15 knots.

Further facts on the same question were yielded by competitive trials of two large battleships, which Admiral Cone summarizes as follows:

**"Delaware" and "North Dakota"; Engines vs. Turbines.**

The trials of the "Delaware" and "North Dakota" present an interesting study in similar ships of the comparative efficiencies of reciprocating engines and Curtis turbines in battleships. These results are shown briefly in the table above.

The "Delaware," which is our latest and perhaps last reciprocating-engined battleship,† showed such an excellent performance on her contract trial that there is doubt in the minds of some of us as to the superiority of the turbine for a battleship of that type and speed. The steam consumption per I. HP. of the main engines was 15.48 lbs. at 12 knots, 12.7 lbs. at 19 knots and 12.9 lbs. at 21 knots.

As compared with the "North Dakota" the main engines of the "Delaware" showed a smaller steam consumption at all speeds, and at 12 knots this superior economy amounted to about *one-third the total consumption*. Translated into cruising radius, this superiority, if maintained on service, is significantly important.

The principal improvements in the "Delaware's" machinery over that of her predecessors consist in: Improved cylinder ratios and reduced clearance in main engines; forced lubrication of main bearings, crank pins, eccentrics and crosshead pins; and the use of superheated steam.

Forced lubrication similar to that of the "Delaware" is being applied to the older vessels. During the present year it will be fitted to the "Vermont," "New Hampshire," "Georgia," "North Carolina," "California" and "Colorado," and, if it proves successful, as rapidly as possible to the other armored vessels of the fleet.

Some difficulties have developed in connection with the use of superheated steam, due to erosion of valves in the steam lines of the "Delaware," and there is still some doubt as to whether the economy gained is not counterbalanced by the increased difficulty of maintenance of plant. We are experimenting with metals suited to high temperatures, and hope to find a valve material to overcome these troubles.

BACKING POWER.—The trials of the three scout cruisers also included tests of relative backing powers, and a full statement af the results was given in our article above noted. The "Birmingham;" with reciprocating engines, showed by far the best backing power, and the "Chester," with Parsons' turbines, the poorest. Admiral Cone gives this same matter in his lecture, and adds:

The commanding officer of the "Chester" states:

However, under all the usual experiences of service, I have felt, during the past four months' experience, no uneasiness as to the adequacy of the backing power, provided I always had six boilers in operation.

The "Chester" has twelve boilers, and on the trials six were used at 10 knots with natural draft.

COMPARISON OF TRIAL RESULTS OF THE "DELAWARE" WITH RECIPROCATING ENGINES, AND THE "NORTH DAKOTA" WITH CURTIS TURBINES.

| | Dela-ware. | North Dakota. | Dela-ware. | North Dakota. | Dela-ware. | North Dakota. |
|---|---|---|---|---|---|---|
| Speed, knots | 12.24 | 12.1 | 19,225 | 19,245 | 21,563 | 21.64 |
| Lbs. water per indicated horsepower per hour, main engines only, lbs. | 15.32 | 20.6 | 12.99 | 12.7 | 13.42 | 13.8 |
| All purposes | 21.05 | 23.94 | 14.52 | 15.92 | 14.8 | 14.408 |
| Total water per hour for main engines only | 55,000 | 76,000 | 205,000 | 238,000 | 312,000 | 349,000 |
| All purposes | 83,463 | 90,984 | 250,549 | 266,711 | 422,931 | 450,965 |
| Total water per knot, main engines only | 4,494 | 6,281 | 10,663 | 12,367 | 14,469 | 16,128 |
| All purposes | 6,819 | 7,519 | 13,033 | 13,859 | 19,614 | 20,839 |

FIG. 10. VIEW OF FINAL ROLLS AT BOTTOM OF CRUSHER HOUSE AND THE LOWER END OF THE 72-IN. PAN CONVEYOR.

*"Comparative trials of the Scout Cruisers 'Birmingham,' 'Salem' and 'Chester'," pp. 220-223.

†Since the lecture was delivered, the battleship "Texas" has been ordered built with reciprocating engines."—Ed.

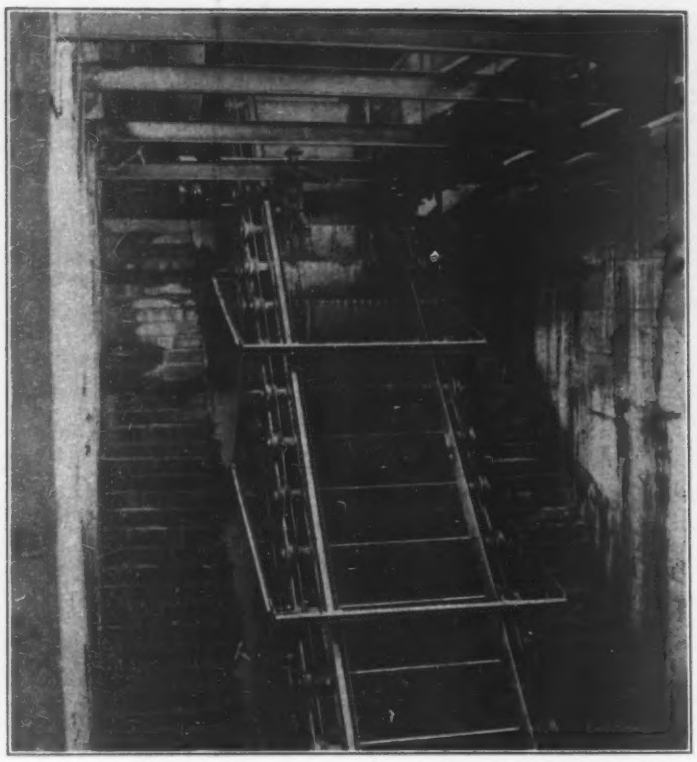


FIG. 11. VIEW OF 72-IN. PAN CONVEYOR ON THE INCLINE BETWEEN CRUSHER AND PRELIMINARY SCREENS.

The adequacy of the "Chester's" backing power is, I believe, debatable, and is a tactical rather than an engineering question.

. . . . Similar trials are to be carried out with the "North Dakota" and "Delaware."

The British battleship "Dreadnought," displacing 17,900 tons, and with 23,000 shaft HP. in Parsons turbines, at a speed of 20 knots was stopped in 3 min. in 5.9 ship-lengths, and at 12 knots in 4.2 ship-lengths, the time for the latter speed not being given [these represent about 2½ times the distance and time required in case of the "Birmingham," 1½ to 2 times those for the "Salem," and about 1½ times those for the "Chester."—Ed.]

### Cruising Radius, Speed and Efficiency.

The problems of turbine economy are then discussed with reference to means for running economically at cruising speeds. The author says:

CRUISING POWER.—The strategical features governing the design of our naval machinery are quite different than in the case of other nations with whose vessels ours are ordinarily compared. Certain European nations, for instance, are building fleets for service in the North Sea. Their probable enemies are close at hand, the probable sphere of their naval activities is limited, and, as a result, their fleets must be prepared to make short changes of base at high speed. The result is apparent in recent British designs, in which the predominant features are high speed and simplicity of machinery at the expense of cruising radius. For their purposes the increased economy gained by the use of cruising turbines is not justified by the increased weight, space and complexity involved.

We, however, must build our ships for service beyond the seas. Economy of fuel at cruising speed is to us of paramount importance, and our problem becomes the difficult one of combining a maximum of cruising radius with an ability to make the speed required by tactical considerations.

This extends even to our destroyers. Their cruising radius should approximate that of the battleship fleet, and this at a sustained speed of 15 knots. We are now considering in the designs of the new destroyers methods of reducing their steam consumption at 15 knots, in an endeavor to build up their cruising radius at this speed. Two methods present themselves. In the one the cruising turbines hitherto shown in our three-shaft destroyers are replaced by small high-speed turbines connected by mechanical reduction gear to the low-pressure shafts. A clutch coupling is interposed to permit throwing out the cruising element at the higher speeds and when backing. The small turbine works the steam from the boiler pressure down to about atmospheric pressure, and exhausts through the main turbines, the power at 15 knots being about equally divided between the three shafts.

The other proposition is to install a small reciprocating engine in place of the high-speed turbine and reduction gear. On account of the low power required for 15 knots (about 450 HP. on each shaft), and because of the comparatively high efficiency of the reciprocating engine when working in the range of pressures presented, the design of an engine which will be satisfactory on service is by no means difficult. A moderate piston speed and forced lubrication can be provided which should ensure ease of upkeep.

Either of these proposed cruising elements can be installed within the weight and space of the cruising turbines hitherto used, and each method promises an improvement in economy of about 20%. The resulting increase in cruising radius may justify the departure from simplicity of plant entailed by the employment of one of these methods, particularly since total disability of the cruising elements would still leave a full-powered plant.

The author then discusses the three important novelties which at present claim attention for ship propulsion, namely (1) Spur reduction gearing in combination with high-speed steam turbines; (2) electric reduction gear, employing dynamos driven by high-speed turbines and low-speed motors on the propeller shafts, this combination affording a very perfect speed control; and (3) Gas engines fed by gas-producers.

MELVILLE-MACALPINE SPUR GEARING.—This apparatus is to be installed on the collier "Neptune," now being built at the works of the Maryland Steel Co., Sparrows Point, Md. The vessel is a twin-screw steamer similar to the "Cyclops," will displace 19,360 tons, and will have a maximum speed of 14 knots. We gave particulars of the type of turbine and gear installation some months ago.* There are to be two 4,000-HP. Westinghouse turbines running at 1,500 r. p. m. on 200 lbs. steam, and for each turbine a gear set reducing the speed at the propellers to 135 r. p. m. for 14 knots speed. For backing, reverse turbines are provided. Admiral Cone says:

> This installation is being made on very liberal terms to the Government, the cost being that of the reciprocating engines originally contemplated, and the Government being duly guaranteed against possible failure.
>
> The principal points to be developed with this installation are the extent of wear on the gears, quietness of operation, and the adaptability of the gears for reversing. In shop tests the gear has transmitted 4,500 shaft HP. for 40 hrs., with an efficiency in excess of 98%, and with no apparent tendency to wear.

On this ship, also, apparatus for remote control of the steam valves is to be installed, and the new Leblanc type of condenser will be used, both as noted on our article already referred to.†

At the 1909 meeting of the Society of Naval Architects and Marine Engineers,‡ there was described and discussed a remarkable proposal, the use of electric motors for driving ships, for which was claimed high economy at all speeds, and great flexibility. Admiral Cone states that this arrangement may soon be tried in our navy. Another electric system has also been considered.

### Electric Propulsion.

GENERAL-ELECTRIC SYSTEM.—Mr. W. L. R. Emmet, an engineer of the General Electric Co., has submitted a form of electric propulsion in which General Electric high-speed turbo-generators drive motors on the propeller shafts at speeds considered proper for pro-

*"Marine Steam Turbines with the Melville and Macalpine Speed-Reducing Gear," Eng. News, April 7, 1910, pp. 412-413.

†The Leblanc condenser was separately described by E. Yawger in "A Novel Condenser Design," Eng. News, Aug. 19, 1909, pp. 204-206.

‡Reported in Eng. News, Nov. 25, 1909, pp. 589-591.

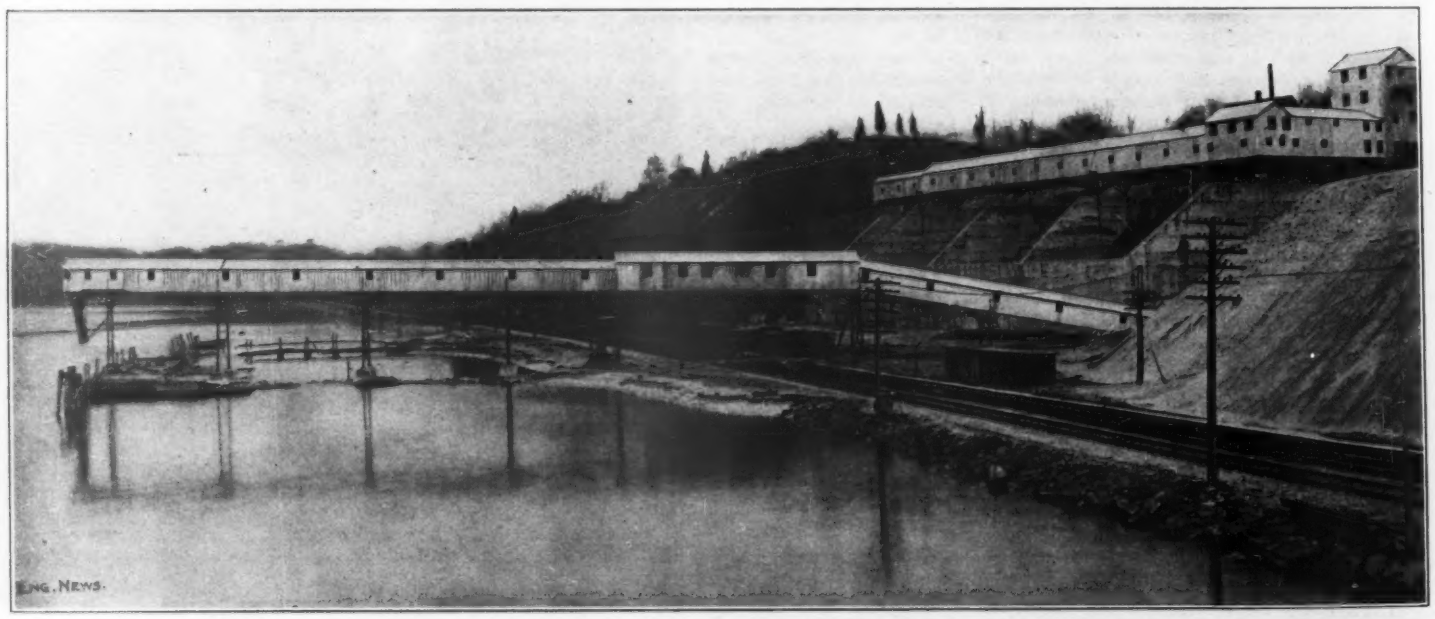



FIG. 12. VIEW OF TOMKINS COVE STONE CO.'S STONE CRUSHING PLANT, SHOWING SCREEN HOUSE, DISTRIBUTING GALLERY, STORAGE BINS AND UNLOADING BRIDGE TO BOTH RAILWAY AND BARGES.

peller efficiency. He estimates an efficiency of transmission of 94%. His installation in a battleship contemplates two turbo-generators, driving four motors on two main shafts. By this multiplicity of units, combined with pole-changing devices on two of the motors, an economy close to the maximum is promised at all speeds above 10 knots.

In the case of a collier, whose speed would probably be near her maximum, the installation proposed consists of two generators and two motors, one on each propeller shaft. The motors would not be arranged for pole changing, but would be equipped with resistance for reversing. At speeds below 11 knots one generator would be used on both motors. At a speed of 14 knots a water rate of 12.6 lbs. per Shaft HP. per hr. is promised, and at 10 knots the water rate is stated to be less than 15 lbs.

It is hoped that this method of propulsion may be installed in a collier authorized by the last Congress, similar to the "Neptune," under conditions similar to those governing the Westinghouse installation in the latter vessel.

Although many of the features of the electric drive proposed by Mr. Emmet have been developed as the result of actual installations in shore plants, there are so many novel features involved that the system will require careful scrutiny before its use in an important vessel is considered. It is difficult to predict what disadvantages, if any, will be found, but the following points will be the subject of special investigation in the trial installation:

(a) Weight as compared with all-turbine drive;

(b) Ventilation of the generators and motors, there being considerable heat generated in the armatures;

(c) Cooling of resistances. Under certain conditions there are large quantities of heat to be suddenly dissipated from the resistances.

(d) The possible failure of the machines or parts of the machines due to access of water;

(e) Complexity of accessories—switches, pole-changing devices, resistances, etc.;

(f) The degree of delicacy of speed control;

(g) The effect of grounds on chronometers, compasses and personnel, the tension being in excess of 2,000 volts.

MAVOR & COULSON SYSTEM.—This system is based on an ingenious spinner motor, which gives three speeds in either direction at maximum motor efficiency, control being had from two double-throw switches.

The motor consists of an ordinary squirrel-cage rotor on the main shaft. Concentric with the rotor and around it, adapted to revolve freely on extensions of the main-shaft bearings, is a spinner, provided with a brake. On its inside surface the spinner is wound to drive the rotor, while on its outside periphery the spinner has a squirrel-cage winding that enables it, in turn, to be driven as a motor by a surrounding stator built into the ship. Thus the machine consists of two motors concentrically arranged around a common axis, either of which may be made to revolve in either direction, or the spinner may be held by the brake while the rotor is revolving. The speed of the spinner, in this manner, may be added to or subtracted from that of the rotor, giving three speeds in either direction without the use of resistances in the rotor circuit, without varying the periodicity of the main circuit and without pole changing.

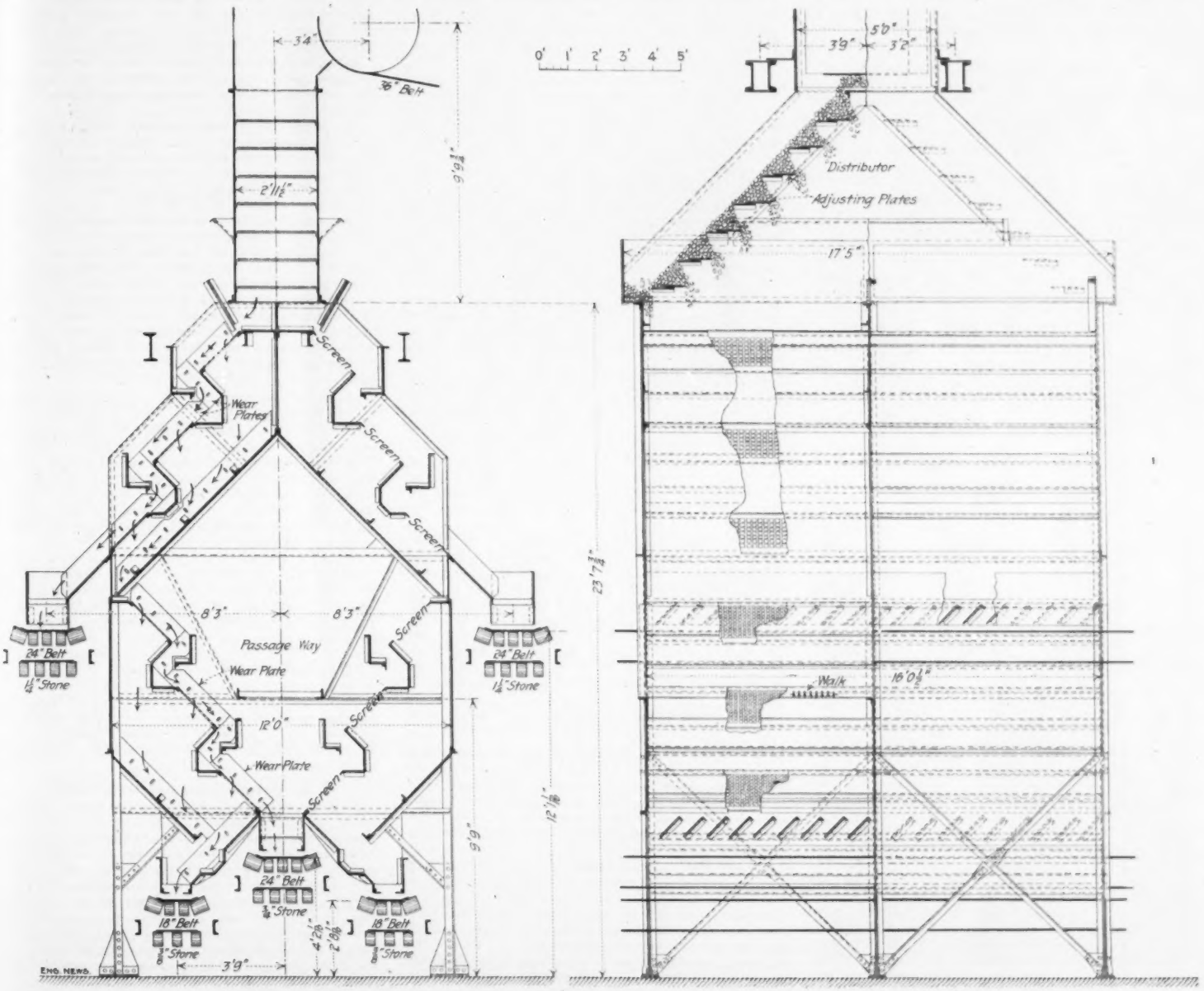
The relative speeds of the rotor and spinner are determined by the numbers of the poles in the spinner and stator.

In the case of a battleship similar to the "Florida" this method would contemplate a three-shaft arrangement, developing 30,000 El. HP. at 150 r. p. m. The estimated loss in transmission in dynamos and motors is 10%, which, it is claimed, would be more than compensated for by the gain in turbine and in propeller efficiencies.

The turbo-generators would have a speed of 1,200 r. p. m. The rotor revolves at 90 r. p. m., the stator at 60. The three speeds at which maximum efficiency would be obtained are, therefore, 30, 90 and 150 r. p. m., corresponding, respectively, to steerage way, to 10 knots and to 20.5 knots.

The equipment would weigh considerably more than an all-turbine arrangement. The over-all diameter of motors would be 15 ft.

An installation of bituminous producer-gas engines driving generators for this method of propulsion, it is reported, is to be installed on a cargo vessel on the Great Lakes during the present year. No reliable data concerning this installation have been received. Its development will be followed with great interest.




Cross Section. Longitudinal Section.

FIG. 13. DETAILS OF STATIONARY SCREEN USED FOR FINAL SEPARATION OF STONE AT TOMKINS COVE, N. Y.

## Number of Propeller Shafts.

Having definitely abandoned the single screw for all important vessels it is almost axiomatic that an arrangement of propelling machinery on two shafts is the best that remains, for reasons of simplicity, and of propeller efficiencies. But we are sometimes forced into a three or four-shaft arrangement for reaction-turbine ships by the excessive length of engine room which otherwise would be required. This is not without advantages, however, in the ease of overhaul afforded by the smaller turbines and in the minimizing of the effect on the total propulsive power of the vessel of damage to one of the units.

As between three shafts and four shafts the latter are preferred for large vessels on account of the probability of better propeller efficiencies. Our lack of experience renders the design of the center propeller in a three-shaft arrangement rather difficult. The proximity of this

propeller to the hull and the likelihood of its being robbed of its water by the wing propellers introduces an element of uncertainty as to its efficiency. It is probable that when properly designed and located three screws will give almost the same efficiency as two or four, yet there are startling instances of trials of triple-screw vessels in which the best speeds were obtained with the center screw idle. We have rejected the three-shaft arrangement for the new battleships, because with reaction turbines the four-shaft arrangement requires a shorter engine room. With impulse turbines the two-shaft design gives more room and greater simplicity on less weight, but in case we go to higher powers in our future battleships three screws will probably be necessary in order to avoid excessively large units.

In the case of destroyers we use three shafts for Parsons turbines and two shafts for the Curtis and Zoelly turbines.

### Internal-Combustion Engines.

Tests have recently been completed at the Norfolk Navy Yard of internal-combustion engines for launches. Nineteen representative makers submitted engines for the tests. Each engine was tested for four or five days in the shop, and an equal length of time in a 40-ft. launch.

As a result of these tests, eight 4-cycle gasoline engines and one 2-cycle kerosene-oil engine were found suitable for naval use.

A gasoline engine to be sufficiently reliable for service use must be of heavy construction and securely mounted in a heavily-built boat. It has been conclusively demonstrated that a lightly-built high-speed engine, however carefully built and operated, will not do. A 4-cycle engine should weigh not less than 45 lbs. per HP., and the 2-cycle engine (for small powers) not less than 35 lbs. per HP. The revolutions should not be much greater than 500 r. p. m.

Designs are being prepared in the Bureau of Steam Engineering for standard gasoline engines for service use. It is probable that eventually the heavy-oil engine will displace the gasoline engine on account of the danger incident to keeping gasoline on board ship. The Department is bending every effort towards the development of an oil engine suitable for small boats.

The use of internal-combustion engines for propulsion of large vessels has long been an attractive subject to naval engineers. Such engines have shown marked economy in large units on shore with constant load when run by producer gas. We are often asked why we do not use such engines in naval vessels. The variations in load, the provision that must be made for reversing, and the necessity for a control of speed sufficiently delicate for maneuvering in a marine installation, present difficulties that have not thus far been successfully met. There are difficulties, too, in connection with the design of a producer suitable for bituminous coal. The size of gas-engine cylinders suitable for marine work is at present limited to about 100 HP. on account of temperature difficulties in larger cylinders. Thus, in the present state of the art, an installation for one of the new battleships would require 320 cylinders, and, needless to say, limitations of space alone would prohibit such an installation. With a gas engine, too, the cylinders are absolutely independent, one of the other; there is no mutual understanding, as with the cylinders of a steam engine, in which each cylinder is very much concerned with the performance of its neighbors. For this reason the problem of simultaneously reversing all the cylinders of a gas engine is a difficult one.

The British gunboat "Rattler" was in commission for about eight months with an anthracite producer, supplying gas to a 5-cylinder, 500-HP. single-acting engine making 120 r. p. m., exhausting into the smoke stack. Speed could not be reduced below 65 r. p. m. A hydraulic clutch was used for reversing; this wore badly and was unsatisfactory. The weight of the installation was greater than that of a steam plant of equal power.

At present, therefore, internal-combustion engines are unsuited for marine installations of greater than 1,000 HP., and in small installations are justified only in special cases. There is, however, prospect of a considerable improvement in the design of bituminous producers, and a well-directed effort to overcome the difficulties which I have enumerated, so that the subject is still very much alive.

Our experience with internal-combustion engines in launches is that their maintenance is very expensive, amounting to 35% per annum of the original cost.

In the British and German Navies heavy-oil engines are used to drive a portion of the dynamo plant on some of the recent vessels. Such an arrangement permits the lighting and ventilation of the ship when, for purposes of overhaul, all boilers are cold.

With us, however, this contingency is so remote that the use of internal-combustion dynamo engines has not been justified. Our principal navy yards are all capable of furnishing current to ships whose dynamo plants are disabled.

### Oil Fuel.

Our experience with liquid fuel, while limited, has been sufficient to convince me that, considered from an engineering point of view, the expediency of its use to the exclusion of coal, in battleships, is clearly indicated.

The principal argument advanced against the use of liquid fuel, in large vessels, is the alleged difficulty and uncertainty of obtaining it in the seaports of the world. This is a strategical question, but I will discuss it very briefly. New oil fields are being developed in many localities where until recently they were unknown. The Argentine Government has directed the installation of oil burning as an auxiliary in their battleships that are being built in this country, and in connection with this appears the statement that large oil fields have been recently discovered in Patagonia. California produces an excellent grade of fuel oil, but we are sending Pocahontas coal around the Horn for use in our vessels on the West Coast. I have seen the statement that the new oil fields in Oklahoma produced last year an amount of oil equal to twice the coal burned by the United States Navy during the same time.

The United States produces more than half the world's oil supply, and it is being shipped abroad for use as fuel in the vessels of foreign navies. It would appear that fear of a difficulty in obtaining oil should not seriously interfere with the adoption of this ideal fuel for use in United States naval vessels.

In time of war we must depend on the fuel stored at our naval bases or carried in our cargo vessels; and it is easier to store and carry oil than coal. With the Panama Canal completed, oiling stations at our possessions in the Pacific, together with some oil-carrying vessels, would afford a certainty of fuel supply at least equal to that now provided for coal.

It should be remembered that all our future destroyers will probably be oil burners, and that their work is with the battle fleet. Thus we are already committed to the establishment of means of supplying oil for the destroyers at all bases at which it would be required by battleships.

That oil-burning battleships have not been more seriously advocated abroad is due entirely to the fact that, with the exception of Russia, no European nation has a supply of oil that can be depended on in time of war. It is logical, therefore, that our nation, producing, as it does, more than one-half the world's supply of fuel oil, should be the first to accept the great military advantages of oil-burning battleships. These advantages have been argued so often that I will not dwell upon them now.

Briefly, with liquid fuel, we can reduce the weights and space required for boilers; reduce the fireroom personnel; eliminate ashes and cinders and practically eliminate smoke, and increase the cruising radius.

The principal advantage, from a military point of view, of oil burning in a turbine-driven vessel, lies in the ability of such a vessel to be driven at full power with but slightly greater effort on the part of the personnel than at low speed, and in the fact that full speed can be maintained for periods limited only by the supply of fuel.

I wish to place myself emphatically on record as advocating oil-burning battleships for our service.

### Improvements in Economy, Battleship Fleet.

In comparing the present coal consumption of the battleship fleet, which means its cruising radius, we will use as a standard that shown on the cruise of the battle fleet from San Francisco to Hampton Roads, on which a considerable improvement was shown over the first leg of the world cruise.

The average coal consumption per knot of the battle fleet at present, referred to a standard speed, is 6% better than that of the best ship on the world cruise.

The average coal consumption per knot of the battle fleet at present, at 12 knots, is practically the same as that at 10 knots on the world cruise.

Since the world cruise there has been an improvement in coal consumption per knot in the battle fleet of 20%.

There is a similar improvement in the smaller vessels of the service.

The armored cruisers have apparently not improved, but are burning a little over 1% more coal per knot than last year.

In consumption of lubricating oil per knot there has been an improvement of 8% from December, 1909, to April, 1910, over that of the preceding year, for all vessels of the Navy. The average cost per knot of lubricating oil for all vessels is now 3.9 cts. This is not as good as the best merchant practice, but is constantly being improved. Our best ships cost less than 1 ct. per knot.

As illustrating the ability of ships to maintain themselves, the cost of repairs due to casualties was 0.4-ct. per HP. during the last year. The cost of new machinery and boilers for naval vessels, included under the head of "navy yard repairs and changes," was 53 cts. per HP. during this period.

Including the power of the auxiliary machinery the average cost of developing 1 HP. in the Navy is now about 2.04 lbs. coal per hour. This includes all expenditures of coal for whatever purpose, and also includes all power developed for whatever purpose. The figure is the average result as shown by the steam logs of vessels in service. The ratio between the average power developed and the maximum power of naval vessels is extremely low as compared with any economical commercial practice. Considering this low power-factor the present result is not bad. The coal efficiency compares very favorably with that obtained under steaming conditions elsewhere. According to reports received, in one very large navy the cost in coal of developing a horse-power-hour is 27% greater than in the United States Navy.

These improvements in coal economy have been principally due to the following causes:

(a) The converting of evaporating plants from single to double effect. The power to distil fresh water sufficient for all purposes is a most essential feature in self-maintenance, and especially so if engaged in a campaign. The economy in making water simply means that the radius of action is increased accordingly.

The gain in economy from the use of the double effect is theoretically 48%. Actual gains of from 35 to 40% are obtained. There is no appreciable reduction in the capacity of the plant.

(b) More careful and systematic firing, induced by analysis of smoke-pipe gases. Most of the larger ships have been equipped with apparatus for sampling smoke-pipe gases and determining the proportion of $CO_2$ therein. With a $CO_2$ percentage of 14 a condition of maximum efficiency is obtained in which there is no excess of air. Should this drop to 5%, as was the condition in many of our ships when this apparatus was first installed, there is a loss in efficiency of 24%, due to excess air.

In some of the ships a record of the $CO_2$ percentages of each fireman is kept, and the ability of the fireman is rated thereby. On one ship, where this system is followed, it was found that the number of buckets of coal required per watch varied progressively from 30.5, with a $CO_2$ percentage of 11.9, to 34.4, with a percentage of 9.0, the amount of steam generated remaining the same.

One of the first things learned by gas analysis was that our boiler casings leaked air. These have been made tight, with a corresponding saving in coal, reported in some cases to amount to as much as 8%.

(c) The tightening of the pressure parts of boilers, particularly the bottom-blow valves. A new type of valve has been fitted on the larger ships during the past year, which removes a serious source of loss that has hitherto existed, due to the inability to keep the valves of the old type tight.

(d) More efficient propellers have been fitted on the "Kansas" and "North Carolina," and are being made for the "Mississippi" and "Vermont." As soon as accurate data on the efficiency of existing propellers under service conditions can be obtained, it is hoped to improve the efficiency of the fleet as a whole by replacing those propellers which are least efficient at cruising speeds.

(e) Greater attention to steam traps. It is found that leaky traps have in the past caused considerable losses.

(f) A more careful attention to auxiliary machinery, particularly to the condition of the valves and steam cylinders. In a battleship at cruising speed, one-third of all the steam generated by the boilers is used in the auxiliaries.

### Full-Power Trials of Battleships.

The table on the next page shows results of the full-power trials of the battleships, held off Guantanamo last winter, as compared with their trial performances.

The trials showed serious weakness in the feed pumps and blowers of the three last named ships. These weaknesses are being corrected. With the exception of these three ships, the trials were most satisfactory. Omitting these vessels, the fleet, with an average displacement 830 tons greater than on contract trial, developed an average speed 0.449 knot greater than the designed speed, and 0.066 knot greater than the average contract trial speed.

On these trials the main engines withstood overloads amounting, in the case of one ship, to 40% in excess of the design load.

An interesting feature, developed by the trials and shown in the table, is the improved propeller efficiency of the "Virginia" and "Louisiana," whose engines were changed from in-turning to out-turning shortly before the trials. Unfortunately for the sake of comparison, the "Virginia's" present propellers differ from those with which she ran her contract trials. The "Louisiana's" propellers, however, are the same.

### Influence of Depth of Water on Speed.

The Board of Inspection and Survey for Ships has recently held exhaustive comparative trials of the "Michigan," "Reid" and "Flusser" over the measured-mile courses at Rockland, Provincetown and Delaware Breakwater, to determine the effect of depth on speed. The depth on the Rockland course varies from 330 to 480 ft.; that at Provincetown from 150 to 160 ft., and at Delaware Breakwater from 135 to 150 ft.

These trials indicate that the "Michigan," with 16,000 tons displacement and 24 ft. 6 ins. mean draft, requires about 1,900 less I. HP. for a speed of 19 knots on the Rockland course than at the Delaware Breakwater, and

RESULTS OF FULL-POWER TRIALS OF BATTLESHIPS.

| Name of ship. | Designed speed, knots. | Contractor's trial. Speed. | Contractor's trial. I. HP. main engines. | Contractor's trial. Displacement. | Fleet trial. Speed. | Fleet trial. I. HP. | Fleet trial. Displacement. |
|---|---|---|---|---|---|---|---|
| Connecticut | 18 | 18.78 | 19,333 | 16,000 | 19.025 | 20,456 | 17,190 |
| Kansas | 18 | 18.09 | 19,302 | 16,000 | 18.900 | 20,273 | 16,890 |
| Minnesota | 18 | 18.85 | 19,896 | 16,000 | 18.420 | 20,685 | 17,200 |
| Louisiana | 18 | 18.82 | 20,443 | 16,000 | 19.073 | 19,793 | 16,692 |
| New Hampshire | 18 | 18.16 | 16,772 | 16,000 | 18.950 | 21,131 | 16,738 |
| Mississippi* | 17 | 17.11 | 13,361 | 13,000 | 17.015 | 13,141 | 13,179 |
| Idaho | 17 | 17.14 | 13,765 | 13,000 | 17.201 | 14,017 | 13,400 |
| Georgia | 19 | 19.26 | 24,948 | 14,948 | 19.003 | 20,847 | 16,414 |
| Nebraska | 19 | 19.06 | 20,947 | 14,948 | 18.900 | 21,389 | 15,950 |
| Virginia | 19 | 19.01 | 22,501 | 14,979 | 19.054 | 20,805 | 16,140 |
| Wisconsin† | 16 | 17.17 | 12,322 | 11,565 | 16.810 | 10,828 | 12,142 |
| Missouri | 18 | 18.15 | 15,642 | 12,500 | 17.890 | 14,706 | 12,959 |
| Vermont | 18 | 18.33 | 17,824 | 16,000 | 15.140 | 8,900 | 16,968 |
| New Jersey | 19 | 19.18 | 22,805 | 14,948 | 18.460 | 19,251 | 15,280 |
| Rhode Island | 19 | 19.01 | 19,800 | 14,680 | 17.651 | 13,092 | 16,201 |

*One propeller injured by tug previous to trial.
†Safety valves set at 27½ lbs. less than designed pressure.

somewhat less power for this speed at Provincetown than at the Breakwater. There is a corresponding effect in the case of destroyers. The "Reid," displacing 700 tons, and with a mean draft of 8 ft. ½-in., requires for a speed of 31 knots about 1,000 less S. HP. at Rockland than at the Breakwater, and less at Provincetown than at the course in Delaware Bay.

### Repair Ship.

Our battleship fleet is, to a greater degree than ever before, self-sustaining as regards repairs to engineering material. This is evident in a decreased amount of navy-yard work. The machine-tool equipment of many of the ships has been increased to as great a degree as is possible within the limitations of space available. In some of the ships small cupolas capable of melting 100 lbs. of brass and 60 lbs. of iron have been improvised, and have proved very valuable for the manufacture of small castings not subject to much stress. A standard oil-burning furnace will be supplied to all the larger ships.

The repair ship "Panther" has rendered most valuable aid to the fleet, and has done much of the work heretofore done at the yards.

For times of war, however, when the ability of the fleet to be self-sustaining may be of the utmost strategic importance, our facilities for repairs are hopelessly inadequate. Realizing this, there have been prepared designs of a proposed repair ship of 13,500 tons displacement, and 14 knots speed, with an equipment which will enable it to—

(a) Make patterns and castings up to four tons in weight. This includes all iron castings for small vessels, and, in case of a battleship, all except main cylinders and turbine casings. (These in any event would be repaired by a welding process.)

(b) Forge anything on board ship except main shafting;

(c) Roll and bend any plate that may be required for the hull or for boiler drums;

(d) Build up lengths of copper piping, and repair and fit defective piping;

(e) Do any required machining;

(f) Carry all materials for the prosecution of this work.

The proportion of foundry and forge equipment is such as to provide sufficient material for its own machine shop and for the machine shops of all vessels of the fleet. Thus, in emergencies, all the equipment of the individual ships, as well as that of the repair ship, could be run at full capacity.

The design of the repair ship provides for convenient and efficient handling of material progressively from its raw condition through the processes of casting, forging and machining in well lighted shops.

The acquisition of such a vessel is of vital military importance to the fleet in that it will, in time of war, enable the fleet to repair damages sustained in action to a sufficient extent to render it seaworthy and capable of renewing action. In time of war or peace it will render the fleet self-sustaining as regards all repair work to machinery, hull or ordnance equipments, except that necessitated in general refitting.

The experience of the world cruise of the battle fleet demonstrated rather conclusively that extensive cruising does not of itself contribute to deterioration of steam machinery, provided the nature of the cruising is such that fixed periods for periodic overhaul are provided.

Undoubtedly, our most important duty as regards the machinery of the fleet is that of upkeep—the taking of the proverbial stitch in time which will prevent the accumulation of trouble in such quantities as to disable the fleet as a fighting unit.

This, however, requires cooperation such as is being accomplished under the present organization.

### Boilers.

The question of the type of boiler for future battleships is one that is receiving due attention. The present Babcock & Wilcox boiler is giving satisfaction, and that company has recently completed an exhaustive series of tests of a sample boiler for the "Wyoming" and "Arkansas." In these tests they more than met every guarantee and, in fact, attained improved economies of evaporation at all rates of combustion.

The boiler stood a further test of forcing under 5 ins. of air pressure, burning 70 lbs. coal per square foot of grate surface, without signs of damage.

Notwithstanding all this, there is a growing sentiment favoring the small-tube express type of boiler for battleships, as giving more elasticity in forcing, especially in a turbine installation, as well as saving weight, on almost the same economy. The experiment station at Annapolis has been engaged in research work for more than a year, with considerable success, in an endeavor to determine proper methods and materials for the interior preservation of our boilers. This, of course, is quite essential if we adopt small or bent tubes in boilers.

In-swinging furnace doors have been fitted on all the battleships and are rapidly being installed in other naval vessels. The design of these doors is such as to cause them to automatically close in the event of a ruptured tube. Already, in the "Georgia," they have prevented serious injury to the fireroom force.

Mosher boilers are being installed in the battleships "Kearsarge," "Kentucky" and "Illinois," to replace their Scotch boilers. The contract for these boilers calls for a guaranteed evaporation of 11 lbs. of water per hour per pound of combustible at full power, when burning 40 lbs. of coal per square foot of grate.

The difficulties heretofore existent with the reciprocating engines of forced-draft blowers have been overcome by the adoption of turbine-driven blowers for destroyers and motor-driven blowers for battleships.

Our new destroyers, propelled by turbines, with liquid fuel and turbine-driven fans, are provided with a machinery installation from which most of the frailties hitherto existent on vessels of this type are eliminated, and which should render them capable of running at full power at any time on demand, and for periods limited only by the fuel supply.

Turbine-driven centrifugal feed pumps are being developed and, although at present they are somewhat handicapped by excessive weight and space required, it is probable that these disadvantages will be overcome to a sufficient extent to allow us to show them in new designs.

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AUTOMOBILE TRANSMISSION EFFICIENCY has been investigated in some tests made at the laboratory of the Königl. Sächsische Mechanisch-Technische Versuchsanstalt in Dresden, Germany. The tests are described by Mr. A. Heller in the "Zeitschrift des Vereins deutscher Ingenieure" of Dec. 10, 1910. They were made on a sliding-gear transmission of the ordinary type giving four speeds and reverse, with direct drive on the high gear. All the shafts ran on ball bearings. Power from the gear box was transmitted to the differential shaft by a bevel gear and pinion, and the differential was of the bevel-gear type. From the differential shaft, the power was transmitted to the rear wheels by two chains. The arrangement was that ordinarily known as the double-chain drive. The drive tested was that of a motor truck made by a German firm. The overall velocity ratios between engine shaft and rear axle were as follows: first speed, 12.1; second speed, 8.5; third speed, 5.4; fourth speed, 3.2.

The transmission, with the differential shaft and rear axle, was mounted on a steel frame resembling that of an automobile. An electric motor was coupled to the first shaft on the change-gear box, taking the place of the automobile engine. The wheels were left on the rear axle, but their rims were removed and wooden pulley rims put in their place. The two pulleys thus formed were belted to two electric generators. The power input and output could then be measured with ammeters and voltmeters in the motor and generator circuits, respectively.

The best efficiency was 92.3%, and was obtained with the fourth speed or direct drive. This result, however, includes the belt loss of about 1 or 2% so that the actual efficiency was really somewhat higher. With the third speed the efficiency was practically as good as with the fourth, rising to above 90% for loads between 18 and 25 HP. The explanation given for this is, that with the fourth speed, the velocity of the rear wheels and generators was considerably higher than with the third speed, thus increasing the windage loss. Moreover, although the drive was direct on the fourth speed, the countershaft in the gear box was kept running although idle. The efficiency on the first and second speeds was between 80 and 85% for loads of from about 10 to 25 HP. With a load of about 4 HP., the efficiency of the low gear went down nearly to 60%.

Mr. Heller calls attention to the discrepancy between the high efficiencies obtained in these tests and the efficiencies of automobile transmissions as actually observed on the road. Road tests frequently show an efficiency as low as 60%. He attributes the difference to the losses induced by vibration due to roughness of roads. The greatest effect of such vibration or jolting is on the chains. In actual use, also, there is an additional loss due to the differential gears being called into frequent operation.

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## A Revolving Steam Shovel for Sewer Trench Digging.

We illustrate herewith a 40-ton steam shovel which is being used in excavating sewer trenches in Portland, Oregon, by the Paquet, Giebisch & Joplin Co., contractors. As seen in the drawing, the shovel is carried on broad-tired traction wheels, rolling on a platform made up of heavy timbers which span the sewer trench. These timbers are bolted together in sections, and as the shovel moves ahead the boom is swung around, picks up the section of the platform at the rear, which has been left free, and swings it around in front. This is one chief advantage of the revolving shovel over the ordinary type for trench work. As seen in the drawing, the platform sections have a U-bolt in the center which is hooked into by a chain from the boom when the platform section is to be picked up and swung ahead.

The shovel is equipped with a special dipper, of 1 cu. yd. capacity, having a flaring cutting edge and three teeth. The bale is secured to the inside of the dipper, so that it does not score the sides of the trench.

Revolving Steam Shovel for Digging a Sewer Trench in Portland, Oregon.

The car body on which the shovel is mounted is 17 ft. 4 ins. long and 8 ft. 4 ins. wide. The shovel has an 18-ft. boom, and the dipper handle is 27 ft. long.

The trench which is being dug at the point shown in the photograph is 8 ft. wide at the top and 4½ to 5 ft. at the bottom, with depths up to 18 ft. The material is clay and hard pan, and it has been found feasible to work at an average rate of eight dipper loads in five minutes.

The shovel crew consists of the engineer, craneman and fireman, with seven laborers to look after the trench bracing, trimming, etc. The work is being done at a cost of about 18 cts. per cu. yd.

The steam shovel was built by the Vulcan Steam Shovel Co., of Toledo, Ohio, to whom we are indebted for the above information.

# The Flow of Water Over Dams.*

By GARDNER S. WILLIAMS,† M. Am. Soc. C. E.

Two formulas are in common use in this country for computing the flow of water over sharp-edged weirs without end contractions. The older one, known as the Francis formula, was devised by Mr. James B. Francis in 1854. As usually written this formula is,

$$Q = 3.33\, L \left( h + \frac{v^2}{2g} \right)^{3/2}$$

where $Q$ = the discharge in cu. ft. per sec.
$L$ = the length of weir in ft.
$h$ = the observed head on weir in ft.
$v$ = the mean velocity of water at the point where the head was measured.
$g$ = the acceleration due to gravity.

From a series of experiments performed in France between 1887 and 1898, Bazin deduced the following expression:

$$Q = \left( 0.405 + \frac{0.00984}{h} \right) \left( 1 + \frac{0.55\, h^2}{(h+p)^2} \right) L\, h \sqrt{2\, g\, h}$$

where $p$ = the height of weir above the channel in ft. and the other letters have same significance as before.

In the two sets of experiments from which these formulas were deduced, slightly different methods of measuring the head were used. In applying the formulas, in very accurate work, care must be taken that the head is measured in a manner corresponding to the formula which is to be used. If this precaution be observed and the weirs are carefully constructed, with sharp edges and level crests, the results from the two formulas will accord with each other and with volumetric measurements within 1 or 2%.

While the sharp-edged weir is thus such an admirable instrument for stream gaging, the expense of constructing such a weir is very considerable. As power or storage dams are found on nearly all streams in the settled part of the country, it is evident that a modification of these formulas, which would allow them to be applied to a dam of the ordinary type, would be of great value to every one engaged in hydraulic work. Until recently, little was known of the manner in which the cross-section of a weir affected the discharge over it. Hydraulic engineers were accustomed to assume that the flow over any dam was the same as that over a sharp-edged weir of the same length under the same head; a procedure which is now known to introduce errors of from 1% to 20%. Although Francis had pointed out about 1860 that the discharge of a weir was decreased by replacing a sharp edge with a broad, flat top, no satisfactory investigations were made of the matter until about 15 years ago. Since then, two important series of experiments on this subject have been performed.

In 1898, M. Henri Bazin published in "Annales des Ponts et Chaussées" several sets of such experiments. He used the formula $Q = mLh$, and determined the value of $m$ for a large number of different dams under heads varying from 0.3 to 1.3 ft. Portions of Bazin's reports have been presented to different scientific societies in this country, but the work, as a whole, has not been translated.

At the Hydraulic Laboratory of Cornell University, there was performed by the writer a series of weir experiments, begun in 1898 for the United States Board of Engineers on Deep Waterways, and afterward continued independently and with the aid of the United States Geological Survey for a number of years. The discharge over various dams was compared with that over a sharp-edged weir of the same length, and of the same height, and thus factors, or multipliers were obtained by means of which the discharges of either the Francis or Bazin formula can be reduced to those of ordinary dams. A sufficient quantity of water was available in the experimental canal, to permit the observations being carried to heads of 4 ft. over weirs 16 ft. in length.

The tables accompanying this article contain the factors found for fourteen dams of common forms, under heads varying from 0.5 to 4.0 ft. To find the discharge over a dam, first compute, by either the Francis or Bazin formula, the discharge over a sharp-edged weir of the same length, and height, and under the same head. Then multiply this discharge by the factor given in the table for the given type of dam and the given head. This gives the discharge over the dam under the given conditions, with an accuracy nearly as great as that of the discharge computed for the sharp-edged weir.

RECTANGULAR DAMS.—The simplest form for the cross-section of a dam is a rectangle, as in Figure 1. When water flows over, there is a vertical contraction beginning at A, the same as in a sharp-edged weir, but the water meets the crest again at E. The sudden change of direction at E and the friction on the surface E B both cause a loss of head and tend, therefore, to diminish the discharge; hence, the discharge under these conditions is always less than that of a sharp-edged weir, and the factor is less than unity. As $h$ increases, the amount of vertical contraction and the distance A E increase, and the distance E B, in which loss of head due to friction takes place, diminishes; the discharge relatively to a sharp-edged weir consequently increases, therefore, the factors increase as $h$ increases until the sheet jumps clear of the crest and the condition is that of a sharp-edged weir. With the 0.48-ft. crest, the points E and B coincide when $h$ is a little less than 1.5 ft., and at heads of 1.5 ft. or greater, the sheet of water leaps clear of the dam. That is, for heads above 1.5 ft. the 0.48-ft. dam discharges exactly like a sharp-edged weir, and the discharge should be computed as such. In the 0.93-ft. dam the same thing occurs at $h = 2.5$ ft. With the 1.65-ft. crest, the factor continually increases and, while it appears that the dam would act as a sharp-edged weir if the head were made great enough, that point was not reached in the experiments.

As the head increases, the velocity across the crest increases and, in the region E B, the friction per foot increases. In the wider dams, a point is thus reached where the increase in friction due to the greater velocity exceeds the decrease in friction due to the greater velocity exceeds the decrease in friction due to the diminishing of the distance E B. Hence, from this point, the factor begins to decrease once more. In the dams more than 3 ft. wide, this point occurs when the head is about 1.5 ft.

In all the dams of this type, the factors decrease as the breadth of the crest increases, since the length E B, over which friction acts, is increased. The height $p$, of the dam above the bottom of the channel, has no effect on the discharge relatively to the sharp edge, provided it is great enough to insure complete vertical contraction.

TRIANGULAR DAMS.—As the vertical contraction existing in the case of the sharp-edged weir is due to the fact that part of the water approaches the crest from beneath (that is, moves nearly vertically upward along the up-stream face of the dam), it follows that if the up-stream face of the dam is inclined, this contraction will be diminished and the discharge correspondingly increased. Table II. gives the factors for two such dams of the type shown in Fig. 2. Since these dams give a greater discharge than a sharp-edged weir, the factor is always greater than unity. It increases slightly with the head, at first, and then, after the head has become as great as 1.5 or 2.0 ft., it gradually diminishes. This subsequent decrease is due partly to the fact that, as the head increases, the form is of less importance in determining the discharge. This may be better understood by considering the effect of an infinite head, in which case the discharge will evidently be entirely independent of the shape of the dam. At low heads, the height $p$ has little influence on the factor, but as the head increases the slope of the smaller dam is not long enough to give its full effect in diminishing the vertical contraction. Therefore, under high heads, the factor is less for the low triangular dam than for the high one.

ROUND-TOPPED DAMS.—Turning again to Fig. 2, it is easily seen that, if the dam were built out to just touch the curve A F E, the discharge would be but slightly affected, while the head would be diminished by the difference in elevation of the points A and F. By thus rounding the crest, the factor will be increased. Acting on this principle, a dam of the shape shown as Type L in Fig. 3 was built and the factors given in Col. 4 of Table III. determined. At heads below that for which the curve was designed, the values of the factors are low due to the friction on the underside of the sheet, but for the larger heads they are higher than the values for the corresponding triangular dam.

The three types I, J, and K, Fig. 3, were used to show the effect of the up-stream slope on the discharge. They all have the same crest, very similar to that of Type L, but the up-stream slope varies from one on four to one on one. The factors for these are also given in Table III. They vary with the head in much the same manner as the factors for Type L. Under high heads, the discharge over Type I is a little less than over Type L, but J and K are always more efficient than L; and of these two K gives the greater discharge.

These tables cover, in a general way, the most common cross-sections of power and storage dams, and by their aid these dams are made available for measuring the flow of streams.

There is also another valuable use to which these data may be applied. At many water-power plants the quantity of water used is fixed by the flow of the stream at low water, while the head is limited by the fact that in time of flood all the water must be discharged over the dam without submerging the lands above. By the use of these tables it is frequently possible to select a form of dam capable of discharging all the flood water under less head than is required by the dam previously in use. The new dam may be higher than the old, by the difference in the heads required by the two different forms in time of flood. This increase of head will give an increased output of power under ordinary conditions of flow. In this way, a very moderate expenditure may be sufficient to permanently increase the capacity of the plant.

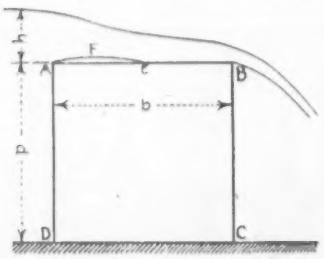



Fig. 1. Rectangular Dam.

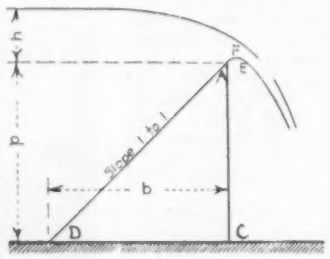



Fig. 2. Triangular Dam, Sloping Face Up-Stream.

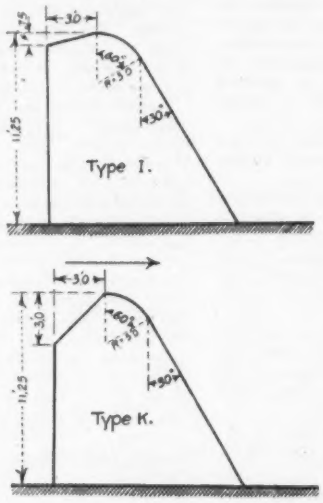



FIG. 3. FOUR ROUND-TOPPED DAM FORMS.

DISCHARGE COEFFICIENTS FOR OVERFLOW DAMS.

Determined by Prof. G. S. Williams.

(To find the discharge over a dam: Compute the discharge over a sharp-edged weir of same length and height, and under same head; and multiply this discharge by the factor given in the table for the dam and head in question.)

TABLE I. —Rectangular Dams, Fig. 1.—

| Head in feet. | Breadth of crest in feet. 0.48 | 0.93 | 1.65 | 3.17 | 5.89 | 8.98 | 12.24 | 16.30 |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.902 | 0.830 | 0.819 | 0.797 | 0.785 | 0.783 | 0.783 | 0.783 |
| 1.0 | 0.972 | 0.904 | 0.879 | 0.812 | 0.800 | 0.798 | 0.795 | 0.792 |
| 1.5 | 1.000 | 0.957 | 0.910 | 0.821 | 0.807 | 0.803 | 0.802 | 0.797 |
| 2.0 | 1.000 | 0.989 | 0.925 | 0.821 | 0.805 | 0.800 | 0.798 | 0.795 |
| 2.5 | 1.000 | 1.000 | 0.932 | 0.816 | 0.800 | 0.795 | 0.792 | 0.789 |
| 3.0 | 1.000 | 1.000 | 0.938 | 0.813 | 0.796 | 0.791 | 0.787 | 0.784 |
| 3.5 | 1.000 | 1.000 | 0.942 | 0.810 | 0.793 | 0.787 | 0.783 | 0.780 |
| 4.0 | 1.000 | 1.000 | 0.947 | 0.808 | 0.790 | 0.783 | 0.780 | 0.777 |

TABLE II. —Fig. 2— p in feet =

| Head in feet. | 6.65 | 11.25 |
|---|---|---|
| 0.5 | 1.060 | 1.060 |
| 1.0 | 1.079 | 1.079 |
| 1.5 | 1.091 | 1.092 |
| 2.0 | 1.086 | 1.097 |
| 2.5 | 1.076 | 1.096 |
| 3.0 | 1.067 | 1.095 |
| 3.5 | 1.060 | 1.094 |
| 4.0 | 1.054 | 1.093 |

TABLE III. —Fig. 3—

| Head in feet. | Type I. | Type J. | Type K. | Type L. |
|---|---|---|---|---|
| 0.5 | 0.968 | 0.971 | 0.971 | 0.971 |
| 1.0 | 1.008 | 1.040 | 1.040 | 0.983 |
| 1.5 | 1.032 | 1.083 | 1.092 | 1.022 |
| 2.0 | 1.041 | 1.105 | 1.126 | 1.040 |
| 2.5 | 1.043 | 1.118 | 1.146 | 1.057 |
| 3.0 | 1.044 | 1.128 | 1.163 | 1.072 |
| 3.5 | 1.045 | 1.136 | 1.177 | 1.085 |
| 4.0 | 1.046 | 1.144 | 1.190 | 1.097 |

*From "The Michigan Technic," June, 1910.

†Professor of Civil, Hydraulic and Sanitary Engineering, University of Michigan, Ann Arbor, Mich.

# Recent Waste-Detection and Meter Work in the New York City Water Department.

By EDWARD W. BEMIS.*

It is proposed to describe briefly the waste detection and meter work which engaged part of my time during the first nine months of 1910 while attending to the manifold duties regularly incumbent upon the Deputy Commissioner of Water Supply, Gas and Electricity of New York.

For lack of funds and organization, little was possible before May, 1910. On April 15 the Board of Estimate and Apportionment appropriated $200,000, out of the water revenues received during the year in Brooklyn, for meter and waste detection work in that borough, and on May 27 it approved the issue of $100,000 of corporate stock for the construction of a building and appliances, etc., for similar work in the other four boroughs. A few new positions for this new kind of work were later created by the Board of Estimate and Apportionment and the Aldermen, and an organization of about 120 men was gradually built up, from men furnished by the Civil Service Board. In immediate charge of the work were placed six men who had had large experience and success in this work in Cleveland, and one who had been trained in pitometer work by Mr. E. S. Cole, of New York.

## Meters.

In the previous eight years as Superintendent of the Water Department of Cleveland, Ohio, I had succeeded, with the able backing of Mayor Tom L. Johnson, in reducing the daily per capita consumption, after allowance for slip of pumps, from 165 to 90 gals. Of the latter, 48 gals. was business use and 42 gals. covered all domestic, public and free consumption, leaks in the street mains, and the meters, and under-registration of the latter. This reduction was accomplished largely, though not wholly, by universal metering, and without any restriction upon the use of water, as distinct from leakage or deliberate waste or stealing.

In coming to New York City, however, it was recognized that the meter system had been so badly administered, and that the rates of charge for metered consumption and for unmetered buildings were so unscientifically arranged, that it would not be wise, at least at the start, to attempt to extend metering. That could only be done when existing abuses and public sentiment had undergone a decided change. Under the city charter, the Commissioner could meter all business places, but could not force meters upon residence consumption without the consent of the Board of Aldermen. This consent, it was supposed, would be, for the present, hard to obtain. It was therefore quickly decided that the chief work of the first year, and at least part of the second year, so far as meters were concerned, would be to put in order and to popularize, so far as possible, the 73,721 meters already in use.

SOLDERING OF METERS.—The 62,000 small meters, smaller than 1½ in., were found to be soldered into place instead of being screwed in with a coupling, as everywhere else in the United States. This greatly increased the cost both of setting and of taking out for repairs or testing, and was a great scheme for enriching the plumbers and rendering the meters unpopular. It also increased the inertia of the Department in testing meters that had been in place several years. Of these meters, 25,000 had been in use over ten years, and 10,000 had been in use for 20 years. Scarcely any had ever been taken out for test unless they had been reported as not registering at all, or unless their registration was so extremely erratic that it attracted the attention of the office force. At my request, Commissioner H. S. Thomson, on Jan. 11, issued the following order:

> It is hereby ordered that henceforth whenever a new meter is installed or an old one disconnected and reset, there shall be a coupling union or flange union connection on the inlet and outlet, both connections to be bored for the seal of this department.
>
> It is further ordered that the property owner shall protect the said seal and also the meter itself by an adequate covering.

This order displaced the soldering of meters that were thereafter set for the first time or reset, but over 90% of the small meters are still soldered in place. It had been my plan, however, that during 1910-11 we would take out and test and properly reset every one of these meters, charging the cost to the property owner when the meter was found to be in need of repair, but assuming ourselves the small cost of the change and test when the meter was found to be correct.

TESTING AT THE YARDS.—During the 30 or more years in which the Department had been overseeing the installing of its 74,000 meters, it had no means of testing any meter larger than 2-in., and could only test one at a time of the smaller meters at the Portland Ave. yard in Brooklyn and at the East 24th St. yard in Manhattan. There were no testing devices in the other boroughs. It was therefore a physical impossibility to test at the yards the meters in use. No attempt was even made to examine and test meters ordered out because they were not registering. Yet this was necessary in order to give the Department the opportunity to learn how the various makes of meters were affected by conditions of service, and which meters were most durable and most accurate after some years of use. The only work attempted was the perfunctory one of testing on a full stream at the yards the small new meters or those that were repaired.

All this was rapidly changed: testing devices were installed at the Manhattan and Brooklyn yards for testing all sizes of meters and for testing a dozen at a time. Apparatus was secured for similar yards in the Bronx and on Staten Island. During the summer, all meters, whether large or small, were tested before being set or reset, and all meters taken out for repair were tested and examined and records made of them before as well as after repairs were made.

TESTING LARGE METERS.—In order to test the large meters, whose removal is expensive, the plan was adopted which has been found successful in Cleveland, of testing them in place. This was accomplished by requiring a valve and test tee, where there was none already, on the outlet side of the meter. Then by taking along an accurate 2-in. meter with a large dial and foot hand and a small length of hose attached to this meter, it was possible to test in place. The following order was issued Feb. 28:

> In addition to the main valve, there should be a valve on the outlet side of the meter.
>
> In setting 1½ and 2-in. meters, put a Tee at the outlet between the meter and the valve, with a short nipple in the Tee and a cap on the nipple.
>
> In the setting of 3-in. meters and all sizes larger, put a Tee at the outlet between the meter and the outlet valve, with a 2-in. opening, but put a short nipple in the Tee and a 2-in. valve on the nipple.
>
> This Tee is being put in for the purpose of testing the meters.
>
> A sample of the new setting will be on exhibition at the Permit Office.
>
> This order will take effect for all meters set or reset after March 15, 1910. It is the wish, although not the order of the Commissioner, that all meters over 1 in. set before then shall be so equipped where practicable.

The results, as expected, were most striking. Of the 408 meters larger than 1 in. that were tested before October, 59 were found to be fast, 96 were slow, and 253 were correct within 2%. While testing these 408 meters, 27 others were found that did not register at all, of which 4 were 1½-in., 9 were 2-in., 2 were 3-in., 6 were 4-in. and 6 were 6-in. How soon this fact would have been discovered by other divisions of the water department and how much revenue the department was saved by the earlier discovery it is impossible to state. At this rate there must be over 700 large meters in the city not recording a drop of the large amount of water daily passing through them. The over-registration of the 59 that were fast amounted in the aggregate to $6,870, or $116.42 per meter when applied to the previous year's consumption, while the meters that were slow were under-registering to the extent of $23,248, or $242.17 per meter. This meant that some consumers were paying in the aggregate for nearly $7,000 worth of water more than they were receiving, while other consumers were receiving over $23,000 worth of water for which they were not paying, to say nothing of the 27 large meters not registering at all.

There was a net loss to the Department of $16,379, or $40.14 on the average for each of the 408 large meters tested. If this average rate of loss applies, as seems likely, to the entire 11,487 large meters of the city, the total yearly loss from under-registration is $461,088.

Of the 116 other large meters that were tested Oct. 1-21, inclusive, the proportion of those badly under-registering was even greater than among the 408 previously investigated.

TESTING SMALL METERS.—After many delays, the materials had at last arrived, during the close of the summer, for setting or resetting the small meters. Prior to Oct. 1, 252 small meters in Brooklyn were taken out, tested, repaired where necessary, and reset. Of these meters, tested as they came, 33, or 13%, did not register at all, and 52, or 21%, did not register on a 1/16-in. stream. Yet a 1/16-in. stream on 26 lbs. pressure, a common pressure in New York, will allow about 25,000 cu. ft. of water, selling for $25, to pass through in one year. The fact that 13%, or one meter in every eight, was out of order and not registering, although never reported by the meter readers, suggests comments which need not be made at this time. If the same ratio holds throughout the city about 8,000 ⅝-in., ¾-in. and 1-in meters are *hors de combat*, while a still larger number are scarcely registering half the water passing through them. In the early part of October, plans were under way for testing the majority of these small meters in place without taking them to the yard.

If the 33 meters mentioned above that did not register at all were passing 30,000 ft. of water per year, which was the average of the ⅝-in., ¾-in. and 1-in. meters that did register at all, though in many instances too little, then the revenue of the Department will be increased $990 by the repair of the 33 meters, to say nothing of the increased registration that will be shown on the 52 other meters which before testing and repair did not register on 1/16-in. and 1/32-in. streams. It may be remarked that scarcely any of the small meters were found to be fast.

The above conservative estimate of $990 of saving a year by the improvement of these small meters gives an average of $3.93 per meter for the 252 meters tested.

REPAIR AND SETTING BY THE CITY.—Following the example of all private and of most public water-works, the city began, during the summer, to set and repair meters with its own plumbers, laborers, wagons, etc. This was almost entirely confined to Brooklyn and was only attempted where requested by property owners, or where the latter had failed to do the work themselves after ten days' notice.

The Department, under the State law, could not do the work free of charge, as in most other places, but put the entire cost, including the so-called overhead charge, upon the property owner. Hitherto the city had turned over all such meter setting and repairs to private plumbing firms. The method now introduced for the first time in New York, of direct labor instead of contract labor, quickly proved a success financially and in popular appreciation. The journeymen plumbers' union favored it, and a committee of master plumbers agreed not to oppose it, at least for a time, and to see whether my prediction would prove true, that the resulting popularization of meters would increase the demand for good plumbing.

After careful investigation a scale of charges was made, sufficient to cover all supervision and office expenses, capital charges, etc. About 21% was thus added to the cost of labor and material. Nevertheless, the total cost was less than half the charges previously made for similar work by private contractors. A few facts relative to ⅝-in. and ¾-in. meters will illustrate this:

The average cost of 18 set by a contractor in 1909 in Manhattan, that were selected as typical of all, was $39.38; the average cost of 16 set in the Bronx, Jan. 1 to Aug. 31, 1910, on delinquent connections, averaged $30.98. The average cost of setting the 677 ⅝-in. and ¾-in.

*New Brighton, Borough of Richmond, New York City.

meters set by a contractor in Brooklyn in 1909 was $17.77! The average cost of the 84 so set in Brooklyn, Jan. 1-Sept. 26, 1910, was $15.81. The cost, however, of 56 set by the city of Brooklyn before Oct. 1, 1910, even after adding overhead charges, was only $7.43, or less than one-half of the charge of private plumbers. Yet the city paid the full going or market rate of wages. Likewise the city disconnected, took to its shop, repaired and reset 72 small meters before Oct. 1, at an average cost of $5.89, while the 76 similar meters repaired by a private contractor the last six months of 1909 cost nearly three times as much, or $16.06 per meter.

Several things contributed to this. While plumbers may add a larger percentage to the cost of labor and material for shop expenses and profit than the city is obliged to do, the bare cost of labor and material is much greater to the plumbers than to the city direct. For example: plumbers pay the wholesaler 40 cts. for a ⅝-in. meter coupling, when they buy in small amounts, and add at least 25% for overhead charges, making 50 cts., while the Water Department paid at wholesale, by obtaining bids for a large quantity, only 20 cts., adding 2 cts., or 10%, for overhead charges. Probably the Department could have in time bought meters in large quantities, at some reduction, as in other cities.

The chief superiority of the city work, however, consists in the labor item. This is due not to any differences in wages, for the City of New York paid as much to plumbers, and more to plumbers' helpers and laborers and for horses and wagons, than did the master plumbers. But when the city does the work it can combine several jobs in the same district in one trip, and also can often test and repair on the same job without any outlay of expense or time in going to the yards, and can avoid some of the trips to the central office, and the inspections required when the work is let out by contract.

Repairs at the yard in each borough involve far less transportation expenses than when the plumber must ship the meter to the works of the meter manufacturer. Frequently a meter only needs a little cleaning out or the adjusting of a pointer.

There was every indication that the public would appreciate this work of the Department, and that it would rapidly grow and serve a useful purpose in popularizing meters.

METERING PUBLIC SUPPLIES.—It has been found elsewhere to be exceedingly important to meter, wherever practicable, the water used for all public supplies, such as parks, schools, jails, and all other public buildings, and to estimate, wherever it is possible, the amount used for fires, street and sewer flushing, street cleaning, etc. Equally desirable is it to meter the supplies furnished free to charities, hospitals, churches, etc. Only in this way can a systematic effort be made to keep down the waste which is usually enormous where there is no payment for the quantity used, and no full realization of the cost of that which is going to waste.

Only a few water departments in this country have been able to secure legislation, as in the case of Holyoke, Mass., under which the department should be paid by other city departments for water used, and all other services rendered, in return for which they pay for all services received from other city departments, and for such taxes as a private company would pay.

But many cities have metered public water-supplies, with great resulting reduction in the waste and leaks. In New York City it did not seem to be necessary for the Department even to pay for the meters and setting. Most of the city departments seemed ready to cooperate and set meters themselves, or have the Water Department do so at their expense. Early in October arrangements were nearly completed for the prosecution of this policy in New York.

EXTENSION OF METERS.—No attempt was made to secure new legislation from the Board of Aldermen or the State Legislature for the extension of meters, but an old regulation to the effect that no one could use water through a hose unless by a permit, and that no permits should be granted without a meter, was enforced more fully than hitherto. Over 500 meters in Brooklyn alone were thus set on the services, not only for the hose, but for other uses.

There was also being rapidly gathered together a trained force of men competent to go ahead under the Stanley Act, passed in 1906, and meter at the expense of the city a few selected residence districts in order to draw conclusions as to the effect of meters and the reasonableness of existing water rates.

### Other Forms of Waste Detection.

It was fully realized that the simplest and most effective treatment of leakage and waste in buildings, namely, universal metering, was not a matter of immediate and complete application. It was also realized that even where metering is universal a large amount of work is necessary in the study of leaks in the street mains, hydrant branches, and service pipes between the main and the building, and in the prevention of stealing of water. Therefore various efforts were put forth to meet this situation.

Hose and Meter.—The so-called hose and meter method, with the use of the aquaphone, detectorphone and the house-to-house inspection, was extensively used and brought large results. The poor condition of some street valves and of most of the curb cocks and boxes, greatly delayed the work and prevented as complete a discovery and stoppage of leaks as would have been possible otherwise.

After measuring the quantity of water flowing into a residence district in the middle of the night, house-to-house inspection by day followed, with the infliction of small penalties of from $2 to $5 for those who did not obey orders to stop leaks in faucets and water closets, etc.

After the pitometer force had been organized, at the end of the summer, plans were under way to determine whether a pitometer, which would cover a large district, would not be a cheaper method of measuring the flow before and after the house-to-house inspection. Doubtless in some cases it would be found cheaper and equally good; but it is believed that there are many districts in which the hose and meter can profitably be used in individual blocks, even if the pitometer be called into play for the district as a whole. Some have failed to see the wisdom of any attempt to measure the water before and after the house-to-house inspection. Several important results, however, are accomplished by the measurement, through the hose and meter, or the pitometer. One can thus prove to critics the extent of the waste that is stopped, and one can know more fully where to concentrate efforts for leak-prevention.

In 393 districts in Brooklyn, running along both sides of a street from one corner to the next corner, or the equivalent of about 197 full blocks, there was not only discovered, but there was stopped, a daily waste of 231,000 cu. ft. of water, worth $231 at the current rate, and costing the Department fully $104 per day, or $37,960 per year. The cost is estimated at $60 per million gallons, or 45 cts. per thousand feet, the figures given by the Chief Engineer of the Department in a letter on the subject in March, 1910. Higher figures should be applied to the value of water on Staten Island and in Queens, and a little lower value in Manhattan and the Bronx, especially in those districts of the low-service supplied direct from the Croton without pumpage.

The portion of Brooklyn covered by this investigation embraced only 23.6% of the 150,000 taps in use, and only 5.5% of the 78 sq. mi. of the borough. In order to realize for the whole year such results as have been mentioned above, a second but more rapid and cheaper survey would be necessary in the winter. On the other hand, the knowledge that such investigations are being made influences other property owners in other districts to prepare for them by reducing the waste in their properties.

There were found to be on the average in every block 35 leaking water closets, 25 leaking faucets, and one leaking service. It is probable that other leaking services and some leaks in street mains existed, but could not be found because of the absence of curb cocks and house meters, or because pitometer investigations were not available until the last of July.

On Staten Island a similar investigation of a district covering 43% of the services in use revealed a daily rate of leakage of 1,903,000 gals., or 22% of the entire daily pumpage. Presumably a complete survey would have shown that about one-half of the pumpage of approximately 120 gals. per day per capita was lost in leakage. The opportunity was not presented for measuring the reduction effected on Staten Island, and indeed the work was not completed by the middle of October, but from the number of large leaks that were stopped it may be assumed that about the same rate of 45% of saving was secured as in Brooklyn. This would mean 856,000 gals. per day, selling at $114 per day, and costing fully three-fourths of this amount, or $85 per day per capita. To be on the conservative side, however, the saving will be estimated at the same value of $60 per million gallons as in Brooklyn. This would make a total saving of $51 per day, or $18,615 per year.

PITOMETER WORK.—After many delays in securing men and supplies, the pitometer work was begun in Brooklyn at the end of July. By the first of October six big leaks had been discovered and stopped, aggregating 1,130,000 gals. per day. Five of these leaks were due to failures of the joints between the hydrant branch and the base of the hydrant, and one to a partly opened blowoff. In no case did the escaping water show on the surface, and the leaks would probably have continued indefinitely had they not been discovered. Their stoppage involved a saving to the Department, even at only $60 per million gallons, of $24,747 in a single year. The leaks were due to careless manipulation of hydrants by dock employees and contractors. There is somewhat less danger of this or of leaks not revealing themselves, at points more remote from the water fronts, yet the danger is always present.

At Coney Island, only one-half of the 4,000,000 gals. per day entering the district in July was accounted for by meters, and the estimates of unmetered consumption. The hourly rate at night between 1 and 6 a. m. was 65% of the day rate, and 75% of the 24-hour rate, but before final studies could be completed the season began to close at Coney Island, and therefore work was postponed until next year, when interesting results are likely to be found.

EFFECT OF PUMPAGE.—Data are not at hand to show the results of the small amount of work done on Staten Island in August and September. The pumpage was kept down in July and August by not allowing any use of water on lawns, streets and highways. Yet the pumpage was 6% greater than during the same months of 1909. In September, although the drouth continued and water was used for street sprinkling and also upon lawns where the house was metered, the pumpage was no greater in 1910 than the year before.

In Brooklyn, records running back many years permit of a more complete comparison. In this borough, too, the principal waste-detection work was prosecuted. The average yearly increase of pumpage from the municipal plant here from 1900 to 1909 had been 5,063,000 gals. per day during the months of July, August, September and October. In 1910, however, the increase was only 4,183,000 gals. per day, and 1,182,000 gals. of this was consumed in the Thirty-first and Thirty-second Wards, supplied before May 1, 1910, by the Flatbush Water Co. The real increase was therefore only 3,001,000 gals. There had been no such transfers of territory to the municipal supply during 1900-9. Yet the rainfall in these four months of 1910 was only 6.50 ins., as compared with 14.41 ins. in 1909 and 13.77 ins. in 1900, and an average of 16.48 ins. for the entire ten-year period, 1900-1909, inclusive. This drouth and the return of some measure of business activity following the dull times of 1907-9, would have normally increased the pumpage six to eight million gallons in 1910, as compared with an actual increase of only three million gallons.

CURB COCKS AND BOXES.—Reference has already been made to the importance of a valve or cock on each service pipe at the curb to assist in the detection of leaks. This is effective not only by furnishing opportunity for the application of an aquaphone or detectorphone to the service pipe, thus catching the sound of running water, but also through permitting house after house to be shut off in the middle of the night and watching meantime the rate of flow of the hose and meter or the pitometer in the district, to determine what buildings have the greatest effect upon the flow in the district.

These curb cocks, however, have other important uses, such as enabling water to be turned off when buildings are vacant or burned, or when, as a penalty for continued waste, non-payment of water bills, etc., the Department may desire to turn off the water. At present this can be done, in most of the city, only by digging up the pavement at the street main and drawing, or otherwise destroying, the tap into the street main.

For a year or two curb cocks have been required on new buildings, in Manhattan and the Bronx, as they had been previously in Brooklyn, but such poor ones were found in use that drawings were nearly completed, by the last of October, for an improved pattern of valve and box, fitted to New York conditions. The leading manufacturers of such devices had agreed to surrender any patents for use within the city limits, and it was expected that we could soon advertise for several thousand and sell at cost to plumbers. They would be required to use these, but might be at liberty to buy goods of the same pattern and quality, if they preferred, from private manufacturers.

In many cities, as now in Cleveland, the Water Department goes even farther, and puts in, with its own labor, all services in the streets and all curb cocks and boxes, even though the first cost of the same, but not the subsequent maintenance, may be charged to the property owner when permit is obtained for the tap on the street main.

It may be remarked that a somewhat similar project of purchasing curb cocks and boxes had been set on foot by Mr. Nicholas R. Hill, when he was chief engineer, about seven years ago, and the Department had purchased over 3,000 curb cocks, but Mr. Hill soon after resigned his position and the curb cocks appear to have been forgotten until discovered by one of my men in a building of the East 24th St. yard.

RESURVEY.—As it had been many years since most of the city had been resurveyed to determine the existing number of fixtures and the amount of frontage rates for unmetered properties, and to determine the accuracy of the records with regard to the frontage rates, this work also was commenced, and about $1,500 had thus been spent prior to October. The men doing this work were also instructed to report all leaks or waste that they might discover during their resurvey. The results of this work, which is only begun, have not yet been compiled.

**Summary of Expenses and Results.**

According to the report of the Chief Auditor of the Department of Water Supply, there had been expended, up to Oct. 1, $44,642 out of the $300,000 appropriated. To this should be added $4,927 expended out of other appropriations, or a total of $49,569. Of this amount, $18,084 was expended for buildings and equipment, which were still on hand on the first of October, and which were in the nature of capital charges. The remaining $31,485 was devoted to operating expenses. The chief results already visible were as follows:

| | |
|---|---|
| Increased registration of large and small meters, per year | $17,368 |
| Charges to consumers for work done, approximately | 1,000 |
| Penalties collected for failure to stop leaks promptly, approximately | 1,000 |
| Value per year of leaks stopped, at $60 per million gallons | 81,322 |
| Total | $100,690 |

In fairness it should be stated that in order to realize the entire saving from the stoppage of leaks, another resurvey would need to be rapidly made in the winter, at an estimated cost of $5,000. On the other hand, in the results above mentioned, no credit is given for the as yet unknown, but considerable, amount of increased revenue from metering 500 places using water extensively upon lawns and from the resurvey of houses, and from the reduction of waste and leaks by consumers living near the districts investigated.

Broadly speaking, therefore, it seems safe to say that with an expenditure of about $50,000, of which about $18,000 was for buildings and equipment, a benefit had accrued to the Department of about $100,000. Some of this benefit, such as the $17,000 from the increased registration of meters, is in the nature of a continuing item of revenue, for at least two or three years. This also applies to the stoppage of part of the leaks, especially of the hydrant leaks, aggregating $24,000 a year. Moreover, the value of the water saved on Staten Island might well be considered as much more to the Department than $60 per million gallons. This is also the gain from the discovery of the 27 large meters not registering at all. Thus the estimate of $100,000 return for $50,000 expenditure will be recognized by most as very conservative. A strong argument could be made for an ultimate saving of $200,000 from this $50,000 of expenditure.

Two other far-reaching results of greater importance than the direct saving of $2 for $1 must be referred to, since they constitute the chief motive in all this work, although not one that can be definitely estimated in dollars and cents. First, this work secures increased pressure for fire service and for people living on the third and fourth floors, who frequently in the past have not obtained any water at all. The water actually supplied may not cost, in a given district, more than $60 per million gallons, but it is hardly possible to over-value the importance of water to a district where there is a scarcity, and where, as in some parts of Brooklyn and Staten Island, there has hitherto been no immediate means available of increasing the supply at any cost. In the second place, it is through restriction of leakage and other waste that one may postpone expenditures of millions of dollars in large extensions in the Catskills and within the city limits.

It is, therefore, most encouraging that the first few months of a systematic effort at waste detection and of meter testing and repairs, with all the delays and handicaps connected with securing appropriations and organizing an entirely new force, should have been so quickly followed by immediate financial results. Even had the returns been no greater than the money spent, the investment would be recognized by most engineers as highly satisfactory.

In the light of all this, and of conditions in Queens not mentioned in this article, and of the importance of guarding against a succession of dry seasons in the Croton before the Catskill supply arrives, I believe that $600,000 can be most economically spent in 1911 in meter and waste-detection work. This would mean $400,000 additional to the amount likely to be left over on Dec. 31 from the 1910 appropriations. A lesser appropriation while not to be refused would simply mean smaller saving and smaller results. With the organization that had been built up by the fall of 1910 the city was assured a return of over $2 for every $1 expended in the ways above described.

## Tests of Rivet Steel for Gripping Power.

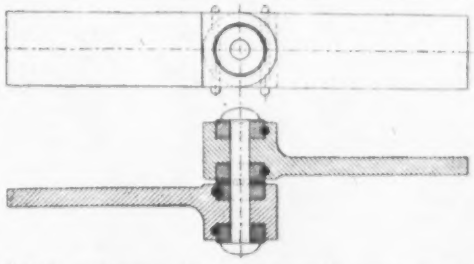
An interesting suggestion is made in "Le Genie Civil" of Nov. 19, 1910, by Mr. Charles Fremont, who has made extended studies of the strength of riveted joints. He believes that steel to be used for rivets should be tested for its gripping power, that is, the force with which it will press together, when used as a rivet, the plates which it joins. Carrying out this idea, he has constructed a machine for making such tests in a uniform and comparable way.

The leading idea in developing this test was that rivet steel in the original rivet rod is not exactly the same as the steel in the finished rivet, and that, in order to get test figures which will apply directly to the strength of rivets, rivets themselves should be tested instead of rivet rod material. In a similar way the gripping power, though dependent upon the tensile strength of the rivet metal, is to be gaged not by tensile tests of rivet rod but by direct test of the gripping power of a rivet. The distinction here is especially important because of the nature of the cooling curve of the rivet metal. The amount of contraction which the rivet undergoes during cooling has great influence upon its resulting grip. The following interesting quotation from Mr. Fremont's article expresses his meaning clearly:

> This measurement of the force of grip is indispensable because it has no relation to the strength of the metal itself. For example, special steels containing nickel-chrome, etc., having an elastic limit of 85,000 or even 140,000 lbs. per sq. in., after being formed into rivets, may give a gripping force almost zero, whereas, an ordinary carbon steel of about 43,000 lbs. per sq. in. elastic limit in its original state, may give a gripping force of 14,000 to 17,000 lbs. per sq. in. of section of the rivet.
>
> If the Technical Commission appointed by the Canadian Government for rebuilding the Quebec Bridge had conducted tests of gripping force, it would have found that special steels containing nickel, chrome, etc., have a low change-temperature, which makes it impossible to obtain an adequate gripping force, whereas ordinary carbon steels, costing a fifth or a sixth as much, give a large and very satisfactory gripping force. This would have led to conclusions differebt from those which the Commission reached. In practice, it is well known that a steel bridge in which the frictional bond due to rivet grip is insufficient, soon begins to rust and to become loose jointed (se disloquer).

For making gripping-force tests in a comparable way, Mr. Fremont has designed a simple machine consisting of a horizontal lever whose fulcrum pin is the rivet to be tested. By loading the free end of this lever, and noting when the lever begins to drop, a measure of the friction in the hinge, and hence of the gripping strength of the rivet, is obtained.

In this machine the hinge ends of the levers and the hinge are constructed as shown in



Detail of Hinge Joint in Fremont's Machine for Testing Gripping Force of Rivets.

the sketch herewith, reproduced from Mr. Fremont's article. The size of rivet for testing is 16 mm. diameter by 100 mm. long (⅝-in. rivet, 4-in. grip length). Under each head and at the contact faces of lever and support are inlaid disks of hardened tool-steel with turned and polished bearing faces. These are used to make the friction due to a given pressure as constant as possible. The remainder of the machine is so simple as to need no further description. An adjustable stop is placed under the lever to catch it as it begins to fall and permits removal of the load and repetition of the test on the same rivet.

Mr. Fremont recommends that when rivets are tested by such a machine, the body of the rivet should subsequently be tested by tensile test and by notched bending test, in order to have a record of the mechanical properties of the material of the rivet as used. He suggests that the 4-in. length of shank permits of obtaining (1) a tensile test piece about 2⅝ ins. long over all, which, with screwed ends and the middle part turned down to ⅜-in. diameter, will permit making a fair test of elastic limit and ultimate strength; and (2) a square piece ⅜ × 7/16 in. by 1⅝ ins. long, which, when notched by a transverse saw cut, will be satisfactory for a notched bending test.

MUNICIPAL AERIAL DOCKS are looked forward to in Modesto, California, according to recent press reports. This is an inland city of some 21,000 population, and its new charter is said to give the city power to construct and operate landing facilities for airships.

## A Land Drainage Project Near Louisville, Kentucky.

Very frequently the problem of getting water off of land where it is not needed is of equal importance with the problem of getting water on to land where it is needed, though usually drainage work does not attain the magnitude of irrigation operations. There is, however, a large field for effective drainage work in the vicinity of a number of our cities where extended areas of marsh land now worthless or worse than worthless because offensive, might be reclaimed to be used for the very necessary truck farms every city requires in its environs. Such a project has recently been started in the vicinity of Louisville, Ky., and has been reported upon to the State Board of Health by Mr. Paul Hansen, Assoc. M. Am. Soc. C. E., State Sanitary Engineer. In addition to being a clear account of the drainage work in progress and in prospect, this report discusses the very interesting relation of this project to the sewerage of the suburbs of Louisville adjacent to the present marshes.

The report, in part, is as follows:

To the southward of Louisville is a large area of swamp and overflow land comprising in all about 80 sq. mi. Of this area 30 sq. mi. lies within the drainage area of a small sluggish stream known as Mill Creek and is immediately contiguous to the City of Louisville. The remaining 50 sq. mi. lies within the watershed of Pond Creek, or to the southward of Mill Creek. The entire area has been rendered practically useless due to frequent overflow and in many places to continuous marshy conditions. Some unintelligent attempts have been made to effect drainage by deepening the channels of the natural water courses, but these attempts have been all but futile and have served to retard a rational movement toward making needed improvements. In the swamp area of Mill Creek watershed the encroachment of city suburbs has created a condition which demands immediate relief. The lack of drainage precludes the possibility of installing proper sewerage facilities and otherwise results in unhealthy conditions and foul nuisances.

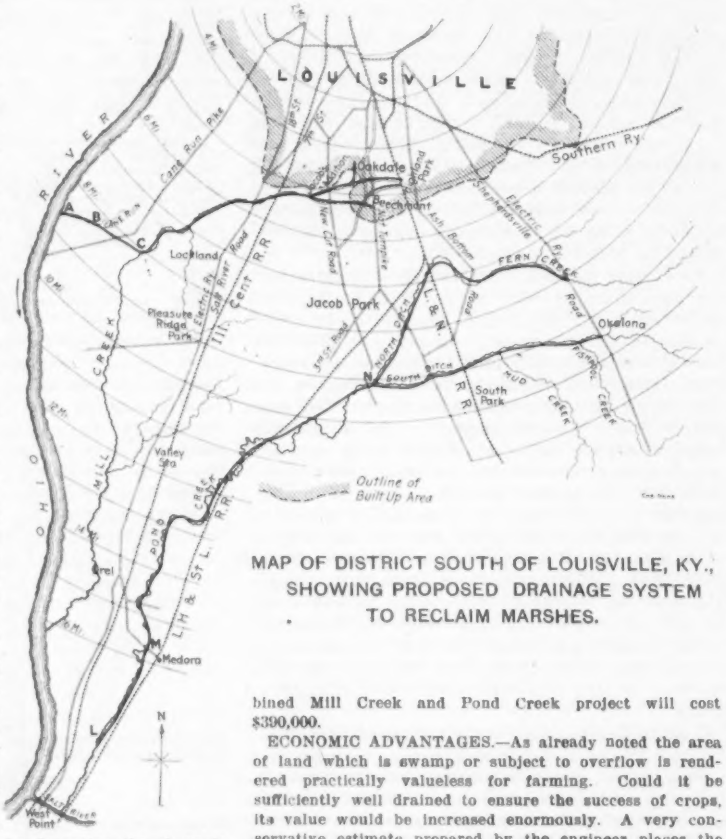
In 1908 a citizens committee was formed on which a number of these suburban communities were represented. This committee engaged the services of Mr. S. F. Crocellus, M. Am. Soc. C. E., a civil engineer who had had broad experience in connection with drainage projects, and instructed him to make a preliminary survey of the Mill Creek Valley with a view to recommending some method of effective and permanent relief. The report submitted by the engineer was so convincing in its presentation of the economical and sanitary advantages to be derived from effective drainage that the Fiscal Court of Jefferson County was induced in May, 1910, to employ the same engineer to make preliminary surveys and recommendations relative to the drainage of the swamp lands of the Pond Creek watershed.

### Outline of Project.

A reference to the accompanying map will show the general relationship of the watersheds of Mill Creek and Pond Creek to each other, to the City of Louisville and to the southern suburbs of Louisville. It was found that by means of a heavy cut from "B" to "C" Mill Creek could be shortened by about 8 miles, and discharged into Cane Run and thence into the Ohio River with sufficient fall to thoroughly drain the watershed. There will be a difference of 17 ft. in elevation in the distance from "C" to "B" and to prevent erosion of the channel two drop flumes will be built. It was found that extremely high water in the Ohio River would reach well up the creek, but damage from this source will be prevented by constructing a levee across the old channel of Mill Creek at "C" and installing flood gates within the new channel between Cane Run Pike and the point "C." The heavy cut between "B" and "C" has already been contracted for and the work is well under way. Having made the heavy cut at "B" "C" it will be a simple matter to deepen and straighten the tributary water courses so as to rapidly remove the run-off from all parts of the drainage area.

The drainage of Pond Creek drainage area is accomplished by heavy ditching between the points "M" and "N." This will furnish ample outlet for all of the watershed lying above "N," provided, of course, that the various water courses are deepened and given good grades. Between "L" and "M" a stretch of comparatively light ditching is necessary, and this has already been contracted for.

The value of all contracts thus far awarded amounts to $70,000, whereas the ultimate cost of the entire combined Mill Creek and Pond Creek project will cost $390,000.




MAP OF DISTRICT SOUTH OF LOUISVILLE, KY., SHOWING PROPOSED DRAINAGE SYSTEM TO RECLAIM MARSHES.

ECONOMIC ADVANTAGES.—As already noted the area of land which is swamp or subject to overflow is rendered practically valueless for farming. Could it be sufficiently well drained to ensure the success of crops, its value would be increased enormously. A very conservative estimate prepared by the engineer places the increase in property value at $3,000,000, or roughly 7.7 times the cost of the improvement. It is generally acknowledged that the drainage of any farm land, unless it involves exceptional difficulties, makes a profitable investment. The conditions, however, in the case of the land under consideration, should render the investment a doubly profitable one for the reason that the character of the soil and the proximity to a great city favor to an unusual extent the success of truck gardening. It is said that Louisville is now obliged to depend upon the neighboring state of Indiana for such garden produce as it requires.

SANITARY ADVANTAGES.—While the economic advantages to be derived from the project are alone amply sufficient to warrant the expenditures involved, the sanitary advantages to be derived are even greater. In the first place the mosquito pest throughout the area covered by the project, as well as the southern part of the City of Louisville, would be very greatly reduced. The relation of malarial fever to mosquitos is too well known to require comment. It is true that Louisville and the suburbs in recent years have suffered comparatively little from malarial fever, yet it is well within the memory of most Louisville residents, that at one time there was hardly anybody within the southern section of the city who had not suffered from this disease at one time or another. With the swamp lands lying to the south of the city the prevalence of malaria may return at any time.

As already indicated, a most serious unsanitary condition is developing on those portions of the swamp lands of the Mill Creek watershed which are occupied by the rapidly growing suburbs of Louisville. These suburbs include the separately incorporated communities of Oakdale, Highland Park, Beachmont, Southern Heights, Jacob Addition, Meadow Brook and several other small settlements. The land about a great many of the residences in these suburbs is in a marshy condition throughout the year and in the case of a great many more the surrounding land is subject to frequent overflow. Cellars and basements are never dry and are often filled with water nearly to the ceilings. The houses, which are generally of the better class, are naturally provided with modern plumbing, but under the conditions existing there is no means of disposing of the sewage to which this plumbing gives rise.

The construction of a system of sewers under present conditions would be an undertaking of prohibitive cost owing to excessive wetness of the ground, and it is very doubtful whether the joints of the sewers could be made with any reasonable degree of water tightness. All this has resulted in the promiscuous discharge of house sewage into gutters, ditches, and sometimes directly into the marshy areas. At the time of inspection the undersigned saw various localities where the sewage and other foul wastes were standing in stagnant pools and undergoing most offensive putrefaction.

With the proper drainage of the territory occupied by these suburbs all these difficulties might be readily overcome, for then it would be possible to install a system of sewers which would not only care for the offensive sanitary wastes, but would also have the effect of lowering the ground water level so that cellars and basements could always be maintained in dry condition.

### Sewerage System Required.

In view of the importance of sewerage to the sanitary welfare of the growing suburbs to the south of Louisville and lying within the swamp area of the Mill Creek watershed, it may be advisable to make a few general statements relative to the type of sewerage system which should be installed, and relative to the procedure advisable preliminary to installation.

In the first place sewerage for all the communities should be considered as a single project, for it would probably prove costly and unsatisfactory for each of the small communities to solve its sewerage problem independently. To this end the authorities of the several communities should get together and establish a sewerage commission with authority to engage the services of competent engineers for the purpose of preparing plans and estimating the cost of a comprehensive system of sewers for all of the communities concerned. The data thus obtained would furnish a basis upon which to obtain funds for the undertaking through a vote of the people on a bond issue. Should the vote of the people be favorable (and it is hardly conceivable that it would not be favorable for the reason that sewerage is so great a necessity that it must sooner or later be provided for) the life of the commission should be prolonged and it should be given new authority to proceed with the awarding of contracts and the supervision of construction.

The separate system of sewerage should by all means be adopted. It is, of course, conceivable that the topography or other conditions may be such that it would be inadvisable to have a single point of outfall, but in any event there should be as few outfalls as local conditions render permissible. If such a system is installed, it should be thoroughly underdrained and the under drains should be discharged into the nearest water course since they will carry only perfectly clear water. The effect of the under drains will be to lower the general ground water level within the built-up districts and render cellars and basements less subject to flooding.

A very costly part of the project may prove to be the final disposition of the sewage from the sanitary system, yet it is an obligation which must be met, for the time has passed when a community may feel justified in annoying its neighbors (even though these neighbors be a few indefensible farmers) by discharging their filth into small water courses which pass through their neighbors' lands. A most satisfactory solution of the disposal problem would be the discharge of the sewage into the sewerage system of the City of Louisville to be carried along with that city's sewage to the Ohio River. The Ohio River at Louisville is a very large water course and is capable of receiving the sewage of all the populated area within the vicinity of Louisville for a great many years to come without creating objectionable conditions, provided the sewer outfalls are properly constructed.

There may be insurmountable practical difficulties in the way of connecting up with the Louisville sewerage system, and in this event the only alternative is the construction of purification works. The best type of purification works to be adopted cannot be outlined in this report, since a more intimate knowledge of local conditions would be necessary. Suffice it to say that there exist at the present time well defined and effective methods of sewage purification which may be made to meet the requirements of almost any local conditions. On the other hand, purification works no matter what their design, require intelligent attention and supervision to insure their proper operation, and if this is lacking, the result will not be acceptable. It may be further added that the operation of sewage purification plants in the small communities is somewhat liable to neglect, and it is primarily for this reason that the discharge of the sewage into the sewerage system of Louisville is especially favored.

Paul Hansen,
State Sanitary Engineer.

## Converting a 56-Year Old Steam Engine for Triple Expansion.*

When the Bromford Ironworks at West Bromwich (South Staffordshire) was taken over by the present owners in 1888, their business consisted largely in the rolling of strip iron made from puddled bar manufactured in the works. The steam required was raised from the waste heat of the puddling furnaces, and there was little need to economize steam.

The large strip mill was driven by a condensing beam engine erected in 1854, having a cylinder of 48¾ ins. diameter 97-in. stroke, fitted with the ordinary nozzles, containing four double-beat valves, two for steam and two for exhaust. It was intended to work at 14 r. p. m., with a boiler pressure of 30 lbs.

As time went on, the present managing director, Mr. F. Scarf, foresaw that steel billets, purchased from outside, must eventually replace puddled iron for this purpose. With the abandonment of puddling, and the use of gas furnaces for reheating, there would be no waste heat available for raising steam, the expense of which would then become a serious item in the cost of production.

As most of the boilers were then approaching the end of their life, but the engine (which had been well made) had an ample reserve of strength, it was decided in 1898 to compound it, and drive with high pressure steam. Also to remove the smaller mill (then driven by a separate engine) into the same building, and drive this also from the same engine.

The details of the alteration were entrusted to Mr. John W. Hall, Consulting Engineer, of Birmingham, under whose advice two new Lancashire boilers, 7½ ft. diameter by 30 ft. long, and capable of working at 120 lbs., were put in. The engine was compounded by adding a McNaught cylinder, 36 × 48½ ins., between the beam gudgeon and the crank shaft. A steel crank shaft was put in place of the cast iron one; a new crank pin was substituted for the original one, which (being of insufficient size), was constantly wearing out, and the connecting-rod was strengthened. The speed of the engine was increased to 20 r. p. m. to get the power required for driving the two mills.

The fitting of the McNaught cylinder presented considerable difficulties, as not only was there at that time a shaft and gearing between the crank shaft and the engine-house wall, but the condition of the ground in the crank pit was of a very doubtful nature. Fortunately, the "lever wall" was well built of good Staffordshire bricks, and was over 5 ft. thick. It was possible to hook the framework carrying the new cylinder on to this wall, and tie it down by means of four heavy bolts secured to girders passing through the foot of the wall.

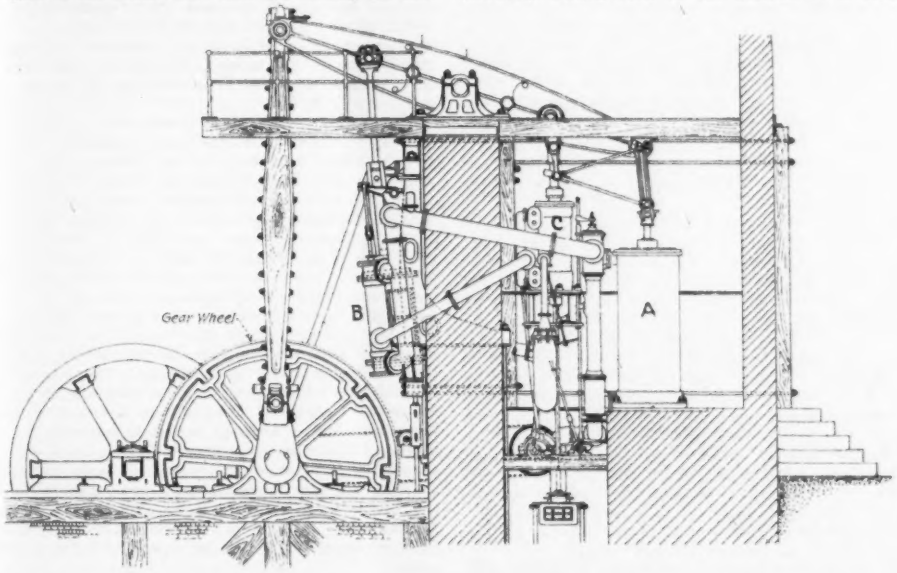
The engine ran satisfactorily, and the addition of a superheater at a later date interfered very little with the piston valve on the high-pressure cylinder. The only fault was that the old governors, which had been worked in, allowed rather more variation in speed than was quite desirable.

An accident happened to these governors 3½ years ago, and before steam could be shut off the speed of the engine increased to such an extent that the rope pulleys, which drove certain portions of the plant, burst with the centrifugal force generated, bringing down a large portion of the roof of the mill. The engine escaped with no more serious damage than the breaking of one bracket, which was easily replaced.

In the present year it was decided to put down a mill for rolling by hand certain small sizes, which were more conveniently produced in this manner than in the larger mill, which was better employed on the wider sections. The economy obtained by the use of the triple-expansion engine, working with superheated steam of over 150 lbs. pressure in a new mill, was sufficient to decide Mr. Scarf to use superheated steam of 200 lbs. pressure for the old beam engine.

Estimates were obtained for new triple-expansion engines, and it was found that allowing for any loss in economy due to the fact that the low-pressure cylinder of the beam engine was not of the most recent design and for the loss in gearing, which would be avoided if the new engine were coupled direct to the mill, the increased capital expenditure would not justify the purchase of an entirely new engine.

Mr. Hall was therefore called upon to devise a scheme for tripling the beam engine he had McNaughted ten years before. This he has succeeded in doing, at a comparatively trifling cost, by the addition of a cylinder




A SIMPLE BEAM ENGINE (BUILT IN 1854) CONVERTED INTO A COMPOUND AND TRIPLE EXPANSION ENGINE (1910).

(A) Cylinder for original simple engine (1854), 48¾ × 97 ins.
(B) Cylinder for compounding (1898), 36 × 48½ ins.
(C) Cylinder for triple-expansion (1910), 24 × 48½ ins.

24 × 48½ ins., set over the air-pump, the portions of the parallel motion having to transmit the additional power being replaced by stronger parts. This cylinder is carried on rolled steel joists let into the side walls of the engine-house. It is fitted with Corliss valves controlled by a Proell high-speed governor, and provided with a knock-off worked by a cord carried into the mill, so that in case of any accident to the governors, a pull on the cord will instantly stop the engine.

It might be imagined from the drawing that the valve gear is crowded and difficult to get at, but in fact the whole is perfectly accessible everywhere. All piston-rod stuffing-boxes are fitted with United States metallic packing, and the cylinder is covered with non-conducting composition protected by planished sheet iron.

Steam of 200 lbs. pressure, superheated to 430° F. at the engine, is supplied from a large Babcock & Wilcox boiler, fitted with a chain-grate stoker. This boiler supplies not only the beam engine, but the vertical triple-expansion engine, a horizontal condensing engine with automatic cut-off (which drives the cold rolling mill), and also a small electric generating set. The boiler is fed with canal water of about 44° hardness, reduced to 4° in a Lassen & Hjort softener.

*Slightly condensed from an article in the "Engineer" (London), Oct. 14, 1910.

## The Report of the Citizens' Committee on the New York Rapid Transit Problem.

With the approval of Mayor Gaynor, a committee of well-known citizens was appointed on Dec. 5 to examine the rapid transit situation in New York and report as to whether the city should proceed with the construction of the Triborough Subway for which bids were received in October, or whether the offer of the Interborough Co. to build large extensions to its system should be accepted.

The appointments to the committee were made by Messrs. A. B. Hepburn, president of the New York Chamber of Commerce, and Henry R. Towne, president of the Merchants' Association.

On Dec. 27, this Citizens' Committee, of which Hon. Seth Low, ex-Mayor of the city, was chairman, presented a report. In this report the committee unanimously recommended that the public authorities accept the proposal of the Interborough Co., with such modification in details as might appear to them judicious.

In view of the interest which has been aroused in this matter, we print below extracts from the committee's report, and also from the reports of its sub-committees on Finance and on Engineering.

### Report of the Committee.

The Interborough proposal which has been conditionally accepted by the Public Service Commission, and which now awaits an expression of opinion from the Board of Estimate, is the outcome of prolonged negotiations on the part of the Public Service Commission and the company. This proposal offers the following advantages:

1. It makes a great addition to the present subway system, which the city owns, so that when the operating leases now in force expire, the city will come into possession of a better and more complete system. This means that when, at any time, not once only but always, a new operating lease is to be made, the city will be in a position to make better terms for operation than it otherwise could.

2. It shortens the original operating lease by 15 years and the operating lease for the Brooklyn extension by 4 years, thus placing the city in control, at one time, of this improved subway system many years earlier than the city could otherwise regain control of the present imperfect system. The present subway is called an imperfect system because it lacks an East Side branch above 42d St., and because it does not provide for the lower West Side. As originally designed it had an East Side branch above 42d St., but the Supreme Court at that time held that the city was not at liberty to spend an amount of money sufficient to enable it to build on both the West Side and the East Side of the city at the same time. This misfortune should now be remedied and not perpetuated. The Interborough proposal also provides for the lower West Side.

3. It places the present proposed additions to the subway system and all further additions that may be made during the pendency of the existing leases for operation, upon the basis of an indeterminate franchise. That is to say; at any time after ten years from the completion of any addition, the city may take over the addition and give it to a different operator, at cost plus a sum not exceeding 15%, such surplus decreasing according to the number of years remaining under the franchise thus terminated.

4. It makes certain an operating company, not only for the present proposed additions to the subway system, but also for every addition that the city may wish to make under the terms of the contract now to be entered into, as it may be adopted.

5. It provides that all such new extensions of the subway system shall be made as additions to the present road. This means that time will be saved in getting to work; that work will begin in four Boroughs at once; and that money will be saved in providing plant for operation. Inasmuch as the city is to enjoy all of the profits for five years after the completion of any addition, and one-half of the profits from operation of these new additions thereafter, the prompt commencement of construction and the saving of outlay for operating plant is of as great advantage to the city as to the operating company.

6. It leaves the city in possession of large resources for the construction of new schools, new docks, new parks, new courthouses, new engine houses, new police stations, and new municipal development of every kind. The sum needed for these purposes is enormous in a city that already adds to its population every year approximately 150,000 people. Every new subway extension tends to increase the rate of the city's treasury for municipal purposes other than rapid transit. It is an object of paramount importance, therefore, to keep the city's investment in subways as low as possible, for otherwise the city will be using its funds in such a way as to increase its own needs for money, while depriving itself at the same time of the credit upon which it must draw to supply these needs.

7. For the traveling public it secures a single fare over the city's subway system as thus enlarged, and makes it certain that a single fare will prevail over all future developments of the system.

When the proposal to abolish the 1 ct. fare originally charged for the use of the footway on the Brooklyn Bridge was under consideration, it was pointed out by the late William Marshall, of Brooklyn, that every afternoon large groups of people gathered about the ferry houses then in general use, some of them waiting many minutes until the 2 ct. fare gave place to a 1 ct. fare

upon the ferries. In other words, the difference between a single fare with free transfers, and a double fare, is felt most heavily by the poorest of the people.

To the multitude of individuals who will use the subway system, a single fare, with transfer, as against a double fare, means a saving to them every year of many millions of dollars. The attainment of this end is an object that no municipality can afford to undervalue.

But even this is not the whole of it. A single fare upon the subway system, with universal transfers on the subway, means the fairly even spread of population all over the city. A double fare, with so-called independent and competing lines, means the concentration of population within the limited areas that can be served by one system or the other. No feature of the subway problem approaches in the gravity of its consequences the importance of making the city's subway system a means of distributing population rather than a means of reconcentrating it. Nothing can be devised so likely to distribute population evenly as a single subway system under one management, which maintains everywhere one 5-ct. fare and which gives transfers wherever a change of cars is necessary.

Certain objections have been raised to the Interborough proposal, which deserve careful consideration.

First. It is said that the financial plan is unfair, in that the city's claim upon the earnings, for interest and amortization of the city bonds, is made subordinate to six other items. The answer is two-fold. The first five items that precede the city's claim are necessary to maintain the operation of the road. If the road were to go into bankruptcy, the Court would authorize the issue of Receiver's certificates to meet these charges, and these Receiver's certificates would precede the payment of interest on any bonds. This being so, the question is reduced to the simple one, whether it is fair to allow the bonds that are to be issued by the Interborough Company to be provided for out of earnings in advance of the city bonds. This committee believes that it is fair, because the Interborough Company proposes to embark in the enterprise a larger and indeterminate volume of bonds than the city, though the property will belong to the city; and it believes further that it is in the city's interest that this precedence should be given to the private bonds, because, by enjoying this precedence, these bonds can be floated at a lower rate of interest than otherwise. Inasmuch as the city is to have one-half of the profits from operation, one-half of the interest thus saved will come to the city.

Second. The proposed terms upon which the Brooklyn Fourth Avenue subway, and other similar additions, are to be operated, seems to some inequitable. The Interborough proposal is that it will operate the Brooklyn Fourth Avenue subway, and other similar additions, provided the city will guarantee it against loss. On the other hand, it asks for one-half of the profits, if and when the operation becomes profitable. This committee believes that the proposal should be amended in this respect. The equitable basis for profit sharing is the incurring of risk. The Interborough being unwilling to incur the risks of operation, in such cases, forfeits its claim to a share in the profits. This committee therefore proposes, in lieu of the terms suggested by the Interborough, that the basis for the operation of the Brooklyn Fourth Avenue line, and other similar extensions, should be as follows: That the Interborough should be guaranteed against loss, that all profits, after operating expenses have been met, should go to the city in full until the advances which it has made under its guarantee against loss have been made good; and, thereafter, to the city and to the operating company in proportion to the amount of capital each has invested in the addition. It might also be fair to provide that, if the returns thus made to the operating company, during the pendency of its lease, do not equal the amount of its investment in operating plant, and the interest thereon, that the city should make good any such deficiency in the returns, in case the operating lease is not renewed.

Third. It is suggested that the Interborough should not be permitted to build on Lexington Avenue, but should be compelled to build on Madison Avenue. Such a condition seems unnecessary, for the following reasons:

1. A subway under Madison Ave. can be connected with the existing subway at 42d St., as well at any time in the future as now. If done at any time it will involve the inconvenience pointed out in the report of the Committee on Engineering.

2. If it be desired to use the tracks on Madison Ave. in future as part of a through system going down to the Battery, this can be done by depressing the tracks low enough to carry them under the Steinway tunnel, the McAdoo line and the present subway. Under such circumstances, an elevator service could connect the deep subway with all the others, and the Grand Central Station.

3. There are no plans ready for building on Madison Ave., nor has legal consent been obtained for the use of that street. On the other hand, plans that are easily adaptable and the necessary legal consents already exist for Lexington Ave. The substitution of Madison Ave. for Lexington Ave., therefore, at the present time, would probably mean the delay of at least a year.

4. The Lexington Ave. subway, if now constructed, can be dissociated from the present subway and related to a downtown line, at any period of renewal of the operating leases. The use of Lexington Ave. at the present time, therefore, does not foreclose its use as part of a different system later if that should be desired.

5. At the present time Lexington Ave. will serve the convenience of a larger number of people than Madison Ave., and for that reason it is likely also to be more profitable. The community will thus be benefited in both ways, for under the Interborough proposal one-half of the profits will come to the city.

Fourth. It is argued by many that an independent line, at any cost, is better for the city than a single system under one management, even though the city is the owner of this system, and even though the management is under public control. The argument by which this view is sustained is that competition is more likely to secure satisfactory operation for both of two systems than if there be only one system.

Even if this be so, it is doubtful whether the argument is strong enough to prevail against the advantages which have been shown to inhere in a complete system owned by the city, upon which only a single fare is charged; upon which universal transfers will be given; and the operation of which is subject to the control of the Public Service Commission.

It is worth while to say, in passing, that the policy of public control of such utilities is very new. It does not involve a violent assumption to believe that experience will constantly make such public control more and more efficient. If new legislation is needed it can doubtless be had.

But, apart from all this, it seems to this committee that the argument in favor of competition in the operation of subways is based, in the public mind, vary largely on temporary conditions. The McAdoo system, for example, enjoys as complete a monopoly in its field as the Interborough has in the municipal field; yet the operation of Mr. McAdoo's system is satisfactory to the public, and the operation of the Interborough system is largely unsatisfactory. Clearly, the reason cannot be found in the fact of competition, for if it be urged that the Pennsylvania tunnel under the Hudson River does compete with the McAdoo tubes, it may be urged that Mr. McAdoo himself, between the Hudson Terminal Building and Twenty-third Street, competes with the subway. If, therefore, it be said that there is competition in both cases, we have the anomaly that competition has produced good results in the McAdoo system and poor results in the Interborough subway.

This circumstance leads the committee to believe that the quality of service given by any corporation at any given time, depends more upon the personal equation than upon the presence or absence of competition. Does anyone doubt, for example, that if Mr. McAdoo were placed in charge of the Interborough system the attitude of the Interborough towards the public would be radically changed? Some day, even the management of the Interborough may learn that the good will of the public is worth having for every reason. When this idea really reaches home, the Interborough will strive as earnestly as Mr. McAdoo now does to please the public.

A system that is overtaxed, as the Interborough is overtaxed during the rush hours, cannot be expected to give service which will not be complained of. Perhaps most of the complaints against the Interborough originate in this condition of things. But there is room, as everyone knows, for a change of attitude towards the public, on the part of the Interborough management, which would make its service satisfactory in many minor respects as to which now it is a subject of just criticism. Such a change of attitude might come from competition; but it may also come without it.

This committee, therefore, would deprecate the adoption of a policy of competition which would forfeit all of the advantages pertaining to the Interborough offer which have been outlined; which would involve the city in useless expense; and in return for which, in the judgment of this committee, the city would be likely to reap disadvantage rather than advantage.

This committee is unanimous in hoping that the public authorities will accept the proposal of the Interborough, with such modification in details as may appear to them judicious, and that they will do this as promptly as possible, and thus put an end to a situation that is already, from the point of view of the traveling public, intolerable, and which becomes worse every day that the settlement is postponed. Respectfully,

Sereno S. Pratt, Secretary. Seth Low, Chairman.

## Report of Sub-committee on Finance.

The chief objection to the Triborough route lies in the fact that as a business project it has not attracted bidders to operate it upon any terms whatsoever. Whether this is due to excessive construction cost, or to other causes, it is not necessary now to discuss. The main fact is that it would mean a leap in the dark if the city should proceed with the construction of this route, without any assurance that private capital would be willing to assume its operation upon terms bearing some fair relation to the money invested in it, with the possibility, or, indeed, probability, that in the end the city would be confronted with the same problem that now faces it in respect to the Centre St. Subway, connecting the East River bridges.

In this instance, the city proceeded, without any assurance of obtaining a lessee, to construct this subway at a cost of about $10,000,000. After the contracts had been let the city found that the only corporation in a position to operate it with benefit to the public was the Brooklyn Rapid Transit R. R. Co., and that the corporation was unwilling to pay the city as rental anything like the interest on its cost.

It was like the case of an oculist making a pair of spectacles of such peculiar power that they would suit the vision of only one living man. If he bargained before making them, he might secure a fair price. If he made them first and bargained afterwards, he would be obliged to accept whatever sum, however small, his prospective customer was willing to pay.

The city also had a similar experience in negotiating for the use of the East River bridges by the surface and elevated lines, and a similar experience with the Tri-Borough route, if built, would not be unlikely; for here would be at least the possibility—and, as many think, the probability—that after the investment of, perhaps, $200,000,000 in this subway, the city, to obtain any use of it, might be forced to operate the road itself at a heavy financial loss.

Expressed in its simplest terms, the Interborough proposal is that out of the total expenditure for construction and equipment, of $128,000,000, it will, if granted a prior lien on revenue, furnish $75,000,000, or as much more as may be required, provided the city will furnish $53,000,000 and the cost of necessary real estate.

The Interborough offer possesses one very marked advantage, from a financial point of view, over that of Mr. McAdoo. Mr. McAdoo fixes the maximum of his contribution from private sources, leaving it for the city to provide the unknown and somewhat indefinite remainder of cost. Should the cost of the road largely exceed the estimates, the city would be obliged to finance that excess, whatever it might be. The Interborough offer, on the other hand, fixes the maximum which the city in any event will be called upon to contribute, leaving the burden of whatever is left to fall upon its own shoulders. Accepting as correct, Mr. McAdoo's own estimate of the cost of constructing his route—and it has been claimed that the actual cost would run far in excess of his estimate—there is an advantage of at least $47,000,000 in favor of the proposition of the Interborough Company, which calls for only $53,000,000 of public funds.

The Interborough's plans contemplate, from a traffic point of view, a complete and harmonious system, serving both the east and west sides of Manhattan Island with satisfactory extensions in both Brooklyn and The Bronx, whereby a passenger can be carried to his desired destination without change of cars for one five cent fare. Mr. McAdoo's plans leave the lower western part of the city wholly without service; leave the present requirements of The Bronx and Brooklyn wholly to the indefinite future, and would require the traveling public, in many instances, to pay a double fare, amounting to ten cents.

On its financial side, therefore, the Interborough's proposal seems to be greatly superior to Mr. McAdoo's, because it will save the traveling public large sums in car fares, and because it involves a much smaller use of the city's credit, and a correspondingly larger resort to private capital.

There are those who, in urging the city authorities to refuse to deal at all with the Interborough Company, and to construct what they call an "independent and competing route," refer to the present subway situation as involving a question of "principle"—as though by that expression a question of moral principle was meant.

To our minds, such academic discussions are quite beside the mark and have no bearing on the needs of the situation, which are essentially practical. The public is interested—and properly so—only in obtaining those additional transportation facilities which will (1) with the greatest celerity (2) furnish the best service (3) at the least cost to the public treasury, and (4) at the smallest expense to private purses for railroad fares.

If these four qualifications are to be found in the offer of the Interborough Co., it is difficult to see wherein lies the sanctity of a "principle" which would call for its rejection and the selection of a route costing more public money, taking longer to construct, affording inferior service and calling in many instances for the payment of double fares by the traveling public.

It seems quite clear that these qualifications are to be found in the Interborough offer, and the public should demand from the opponents of its acceptance some better reasons than can be found in appeals to prejudice against private corporations and in vague references to the benefits of "competition."

Competition is a most desirable thing for the general public, when it can be made effective. It is effective in almost all private trade conditions, because it then tends either to reduce prices or improve quality, or both. But

in the case of the business of public-service corporations it is a will-o'-the-wisp which people would cease to chase if they would but stop to consider that the conditions of such businesses are such as to make monopoly not only natural, but, also—if properly regulated by public control—eminently desirable.

For example, those cities which have suffered from the evils of telephone competition, wherein a nominal reduction of rates has been far more than offset by the additional cost of having to install two or more systems, each providing inferior service, would be glad to obtain the economies and efficient service of a well-regulated monopoly.

Attempts at competition in the matter of light, heat and power service have been almost universally short-lived and unsatisfactory. The city of Cleveland has recently had a similar experience in the case of its surface transportation lines, and the people of this city would be chargeable with short memories indeed if they did not remember how expensive to them has proved the breaking up of the Metropolitan Street Railway system, with its resulting curtailment of transfer privileges.

The feature which appears in both the McAdoo and Interborough proposals, of establishing a prior lien on revenue for interest and amortization charges on the private capital invested is not altogether without its advantages to the city. In the first place, it may be said that the many advantages of using private capital for the building and equipment of subways seems to be opposed by only one offset—i. e., the higher rate of interest which private borrowers must pay. Whatever tends to reduce this interest rate reduces correspondingly this disadvantage. By conferring upon the bonds issued by the operating company a priority of lien upon revenue, these bonds will be made so attractive to lenders as to be placed *ipso facto* almost, if not quite, upon a parity with city bonds.

Now the city, under either the McAdoo or Interborough plan, besides owning the projected subways, becomes a partner in the respective enterprises. It will be entitled to one-half the net profits of operation. If the company's fixed charges are reduced by a lower interest rate on its bonds, the net earnings are correspondingly increased and the city, equally with the operating road, becomes the gainer. The whole basis for objection to this feature of the McAdoo and Interborough proposals seems scarcely more than a sentimental one, because it is, of course, obvious that if the city were to provide *all* the funds necessary for construction and equipment, the interest and amortization charges would still have to be met from revenue, and that no disadvantage results from the city being relieved of the necessity of providing a part of these funds, even if a prior lien be established in favor of private creditors.

It should also be borne in mind that, if the offer of the Interborough Rapid Transit Company is accepted, and should prove to be unsatisfactory, the city will have the right, after ten years, to acquire the new lines built under the offer of the Interborough Rapid Transit Company, and by so doing to terminate such unsatisfactory arrangement; the offer of the Interborough Company providing for this on reasonable terms. In the opinion of this committee, however, it is extremely unlikely that such steps will ever be taken by the city. The mere fact that the city has such right should, of itself, be sufficient to prevent the Interborough Rapid Transit Company from operating the road against the public interest.

Respectfully submitted,

Isaac N. Seligman, Chairman; Francis L. Hine, Darwin P. Kingsley, Edgar J. Levey, William A. Nash, William H. Porter, Frank A. Vanderlip, Seth Low, *ex-officio*, Sub-Committee on Finance.

## Report of Sub-Committee on Engineering.

The first element to consider is that of the rolling stock for on that depends the cross-section of any structure adopted, and thus very largely affects capital outlay. The best available experience as to the proper size of car is the 30 years' experience on the elevated roads, and the 6 years' on the subway, and it is our opinion that substantially the length and width and height of such cars should be adopted for any future railway.

The plans of the Triborough System provide for a tunnel section to accommodate a larger car than those now in use, apparently on the theory that trunk-line suburban cars might be used for a through service in outlying districts, and that the district urban cars might be made to offer greater capacity.

Larger cars mean greater standing room, but not more seats. What is needed are seats, which are regulated by the length of platforms and not by size of car. Further, larger and heavier cars would take longer to load and unload, even with side doors, and add to cost of operation, requiring, as they would, greater power, which would be continuing in the non-rush hours, when only seats are called for.

The mixing in of suburban through car service with strictly urban service, running on continuous 90 seconds' headway, is impracticable from an operating point of view; in other words, the operation of urban trains in a continuous procession precludes the squeezing in of interurban trains. This is to say nothing of the impossibility of operating interurban cars over the East River bridges.

Therefore, it does not seem worth while to spend 20 to 30 million dollars unnecessarily in building a tunnel with so large a cross-section. It would be well, however, to slightly enlarge the cross-section of any new tunnel over the old one to gain a little more clearance and some additional depth for track construction.

As to side clearances, we have been advised that during the entire period of the operation of the existing subway no lives have been lost due to scant clearance. It has been held by some that ventilation will be more satisfactory in a tunnel with a larger cross-section. This we believe to be a fallacy, even with curtain walls between tracks, for the farther a train is from its surrounding enclosure the less will be the piston effect. We do not approve of curtain walls, even for express trains, as the draft of air preceding and following a train will be disagreeable at the open stations. The most effective method of ventilation will be by mechanical appliances between stations. The greater the tunnel cross-section, the greater volume of air to exhaust, and the greater the cost of ventilation.

In the Triborough plan, provision is made for so-called "Reservoir Stations," to insure the more rapid handling of trains. As the measure of ultimate capacity determined by the Commission, namely, ten-car trains on 90 seconds headway, is to be realized on the present subway, where reservoir stations are not used, as soon as all cars are equipped with center doors and speed control devices are installed at stations, we believe that the general use of reservoir express stations, involving as they must, in many instances, annoyance to the public in stair-climbing, at double-storied stations, and always at great additional cost, is not justifiable.

Where a subway is to be constructed below mean high water it becomes a serious proposition, and every effort should be made to keep the floor as near mean high water as possible. The Triborough route in Canal St. is planned to go 40 ft. below mean high water with a rectangular cross section. The estimate for this work is $5,200,000 per mile of single track, which is more than double the actual cost of the Battery tunnel under the East River, which was $2,200,000 per mile of single track.

Also, where it crosses under Harlem River, the top of the tunnel construction may apparently be raised some 8 ft. without encroaching upon the plane of dredging established by the Federal Government, thereby reducing the gradients and cost of construction.

From the point where the local service stops at the City Hall station down to the Battery, the expense of the construction as laid out on the Triborough plans, is very largely increased on account of the unnecessary depth of the excavation. This embraces what is known as "Route 5, Sections 1 and 2." The only advantage that the proposed plan would give is the use of three tracks for the short distance between the Cortlandt and Rector St. stations. Inasmuch as the traffic is carried on two tracks from the City Hall station to the Cortlandt St. station, and for part of the distance between the Rector St. station and the terminal, it does not seem that the increased facilities obtained by the addition of a third track at these two stations is commensurate with the great cost which they entail.

The fact that the two tracks from City Hall are expanded into three tracks at Cortlandt St., necessitates the use of a mezzanine floor to provide access to the double platforms at these two stations. This gain requires the lowering of the whole system from City Hall Square to Battery Park, to this additional depth below mean high water equivalent to the height of the mezzanine floors. This necessitates a very difficult and expensive method of construction for these two sections, as the material encountered below mean high water is largely fine quicksand.

For the express service from City Hall south, a two-track system to the point where the terminal at Battery Park begins would seem sufficient. By eliminating the third track and the mezzanine floors from the two stations at Rector and Cortlandt Sts. the floors of the subway can be raised to a point so near mean high water, that this work can be done without the use of unusual and expensive methods. This would mean a probable saving of upwards of one-third of the cost of these two sections, the bids for which aggregate $13,540,658, without any provision for extras, etc.

It therefore appears that in Canal St., at the Harlem River, and below the City Hall there is room for large savings in cost, by changing the design.

In our opinion, the route, plans and specifications of the Triborough system contain so many objectionable features that in the interests of public convenience and safety, and from the point of view of a wise use of the taxpayer's funds, their adoption as they now stand is impracticable.

We also believe that a rational route, competitive with the Interborough, is perfectly feasible, but it involves a material change of location from that of the Triborough order to serve best the city's needs, and it would involve at least another year's delay to prepare the same, and to conform to all the legal formalities.

The plans proposed by the Interborough Company contemplate that the extensions of the existing subways are to be based on the original plans, without substantial enlargement of cross-section, and without reservoir express stations, modified, however, to include longer platforms and other improvements that experience has shown to be desirable; and inasmuch as the proposed routes also conform to the principles hereinbefore set forth, there does not appear to be, from information at our command, any engineering objection to these proposals, although there are several very important contract and financial questions that no doubt will be considered by the Committee as a whole.

We would also call attention to the wisdom of giving special study to perfecting facilities at stations, with a view to public convenience and safety; such as locating exits and entrances, where possible, so as not to obstruct sidewalks; cash-trays at ticket windows, like those in use in the Hudson-Manhattan tunnel system; measures for avoiding conflicting streams of in and out-bound passengers; and the locating of all station platforms on straight lines and not on curves.

Your Committee could have expanded to greater length their comments upon the two proposals for subway development now before the city, but they believe they have sufficiently discussed the salient points to warrant them in unanimously agreeing upon the following conclusions:

That the Triborough System does not as at present planned, follow the best possible route. It is unnecessarily expensive structurally, and of unknown ultimate cost to the city. It does not afford continuous train service, and at best would be a weak and heavily handicapped competitor with the Interborough System.

That a well located line, efficiently reaching all territory now suffering for lack of rapid transit, can be planned on an attractive competitive basis, and on constructive lines, at much less expenditure.

That the extensions proposed by the Interborough will round out an existing system, fulfilling all reasonable present requirements, and on a basis in which the cost to the city is absolutely defined, and readily provided for.

We are of the opinion finally that, should the policy be adopted of constructing an independent rapid transit system, plans and specifications on a new route for a Triborough System of normal cross-section, with an upper East Side and a lower West Side leg, cross-connected in the neighborhood of 42nd St., and furnishing through car service to Brooklyn, should be prepared as quickly as possible. The probable time of so doing, coupled with legal formalities, is estimated at not less than twelve months. By such a method competitive bids may, in our judgment, be obtained, not only for municipal construction, but also for private operation, this procedure, we think, being such as would stimulate bidding by many rather than by few interests.

On the other hand, should the policy be adopted of having subways built and operated as extensions of the City Subway System, substantially in accordance with the terms of the latest proposal of the Interborough Company, the contract should provide that all plans and specifications shall be prepared under the joint supervision of competent representatives of both parties; that the Jerome Ave. branch in the Bronx shall be an integral part of the subway extensions and not of the Manhattan elevated; that the expenditure of all funds, both public and private for both construction and equipment, shall be under the strict joint supervision of competent representatives of both parties; that suitable clauses shall clothe the city with the right to enforce proper regulation for both public comfort and safety, such as seats for all passengers in "off" hours of the day, including Sundays, and courteous treatment of the public by the company's employees; that future extensions and branches shall be constructed and operated on terms that will be fair to both parties; and for other items for the city's protection that will occur to the city's representatives as needing inclusion in the contract apart from those incorporated in the company's offer.

Respectfully submitted,

Charles Booysmith, Chairman; Alfred B. Boller, William H. McCord, Samuel Rea, Franklin Remington, William J. Wilgus, Seth Low, *ex-officio*, Sub-Committee on Engineering.

THE HIGHEST RAILWAY POINT IN THE WORLD is generally supposed to be on a branch line of the Antofagasta & Bolivia Ry., which reaches an altitude of 15,800 ft. above sea level. In the magazine "Peru To-Day," however, this distinction is claimed for the Morococha branch of the Central Ry. of Peru, which reaches an altitude of 15,865 ft. and has the highest station in the world at Ticlo (the junction with the main line), 15,665 ft. The maximum grade on the line, extending from the port of Callao, is 4½%. This railway is of standard gage, while the Bolivian line mentioned has a gage of 2½ ft. It is reported, however, that a branch of this latter line will extend to an altitude of over 16,000 ft., as noted in our issue of Oct. 6, 1910.

## An Unusual Case of Bridge Erection by the Cantilever Method.

The bridge whose erection is illustrated by the two views Figs. 1 and 2 herewith was constructed under rather exceptional conditions, which led to a novel solution. It is the crossing of the Idaho & Washington Northern R. R. over the Pend Oreille River near the northern terminus of the line at Metaline, Wash. The structure consists of one 145-ft. span and one 280-ft. span, both riveted-truss deck spans, with track grade 140 ft above water. The location of the crossing put falsework out of the question, as the water is very deep (up to 200 ft.) and the current is rapid. Cantilever erection was therefore resorted to. Under ordinary circumstances this would have been carried on from both ends, so that the maximum projection would be about half the length of span. But at this location only one bank was readily accessible, and to get material over to the other bank would have required an expensive cableway plant. For this reason it was decided to erect wholly from one end. The shore span adjoining the channel crossing at this end was designed to be able to serve as anchor arm for this purpose.

Fig. 1.

The special outline of the shore span is apparent from the view Fig. 2. This span weighs about 300 tons. Its land end was loaded with 600 tons of steel rails as counterweight for the 700-ton channel span. Shore span and channel span have a common shoe on the pier at their junction, designed to be capable of transmitting the bottom-chord compression during erection. Tie-bars joined the top chords during erection, and were taken out when the outer end of the channel span was brought to bearing on its abutment on the opposite bank.

All material was set by derrick-car. The end posts, weighing 17 tons each, were the heaviest pieces handled.

The bridge material was manufactured by the Pennsylvania Steel Co., Steelton, Pa. Erection was done by McCreary & Willard, of Spokane, Wash.

Fig. 2.
TWO VIEWS OF THE ERECTION OF PEND OREILLE RIVER BRIDGE, IDAHO & WASHINGTON NORTHERN R. R.

## Sidewalk Paving Slabs of Destructor-Clinker Concrete at Nottingham, England.

The clinker from refuse destructors is used in making concrete slabs for sidewalks in Nottingham, England, as also at various other places in the country named. The plant used for this purpose at Nottingham was described recently by Mr. J. Terry, Superintendent of Cleansing at Nottingham, in a paper before the Association of Cleansing Superintendents. The plant was put in operation in June, 1905, and in the succeeding five years put out about 75,000 sq. yds. of paving slabs, of which 18,500 were manufactured in the year ending June, 1910. The flags have a total thickness of 2½ ins., of which 1 in. is a granite face composed of one part cement, three parts granite, while the 1½-in. body of the slab is composed of equal proportions of cement and destructor clinker. The slabs are made in widths of 2 ft. and in lengths of 2, 2½ and 3 ft. The plant was described by Mr. Terry as follows:

It consists of a grinding mill, similar to a mortar mill, but with perforated bottom through which the clinker is screened when broken to a suitable size; a set of vertical two-throw belt-driven pumps having rams of 1¾-in. diameter and 5-in. stroke; an accumulator having a ram 4 ins. diameter and 8-in. stroke, working at a pressure of 2,240 lbs. per sq. in., with automatic knock-off valve to prevent the pump working against pressure when the accumulator reaches a certain height; a three-slab hydraulic slab-making press which gives a pressure of 400 [long] tons on each slab, and a vacuum pump for working the lifting tackle which takes the slabs out of the moulds; the whole of the plant is driven by a motor with electric current generated by steam derived from the burning of the town's refuse.

The arrangement for removing the slabs from the molds is very ingenious, as they are not handled in any way; a ram working under the mold pushes the slab out of the mold and it is received on its upper face by a perforated plate, the holes in which are connected by suitable piping to the vacuum pump; this plate with its traveler swings the slab over on to its receiving tray, and when nine or twelve of these are piled up they are removed on a trolley to the shed, which is supplied with rails, on the lower flange of which the trolley runs; by turning a screw the floor of the trolley is lowered so that the bottom tray rests on the top flange of the girders, the trolley may then be removed to the slab-making press.

Difficulties with "blowing" caused by pieces of lime found in the clinker and a method of overcoming the difficulties were thus described by Mr. Terry:

The granite and cement was put in the mold first in sufficient quantity to make a face 1 in. thick, and on to this was then shovelled the clinker and cement; it was found, however, that the operation of dropping the latter on to the former resulted in a portion of the granite being displaced, and instead of there being a face of 1-in. thick throughout, in some places it was only ⅛-in. thick. If there happened to be a very small piece of lime in the clinker backing where the granite face was very thin, "blowing" took place, caused by the expansion of the lime. The trouble was overcome entirely by, first, allowing the ground clinker to be thoroughly saturated with water, which breaks up the lime and renders it practically inert, and second, by making the slabs in two operations, that is, after the layer of granite and cement was filled into the molds, giving a gentle pressure on the materials in the mold so as to render it hard enough to allow of the clinker and cement being shovelled on to it without affecting the thickness at any point; since this system was adopted a defective slab is almost unknown.

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A LONG CONCRETE GIRDER BRIDGE has recently been completed by the Southern Ry. Co. for its two-track line across the French Broad River near Asheville, N. C., between which city and Craggy, N. C., a new alignment and construction has been in progress. The bridge is 733 ft. 10 ins. long and consists of a series of twenty-two 30-ft. spans, each span of three parallel reinforced-concrete girders, all resting on a solid concrete pier extending, on a skew of 30° to the axis of the bridge, clear across its width. The three girders are spaced 13 ft. 4 ins. c. to c., the outside two each 24 ins. wide and 7 ft. 7 ins. deep and the middle girder 36 ins. wide and 9 ft. 7 ins. deep, both reinforced heavily. The roadway is carried on a solid concrete slab between these girders 24 ins. deep in the middle and with large brackets reaching down to the supporting girders. The spans are divided into series of four at each of which the piers are 4 ft. thick at the top, the intermediate piers being but 3 ft. thick. The foundations are carried down to solid rock. The girders are continuous for the entire length of the bridge but on each pier, at the foot os the small brackets reaching up to the girders, a grooved expansion joint was made by placing along it two thicknesses of ordinary tar paper. Further expansion was provided by a 2-in. space at each end of the continuous girder.

Design loads and stresses were: Loading, Cooper E-50 + 100% impact; tension in steel, 12,500 lbs. per sq. in.; compression in concrete 450 lbs. per sq. in. Work was completed in May, 1910. The design was designed in the office of Mr. W. B. Crenshaw, Principal Asst. Engineer, Construction Dept., Southern Ry., and the whole work was under the direction of Mr. W. H. Wells, Chief Engineer of Construction. The approximate cost of the entire structure was $125,000.

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The White Star Steamship Co. is about completing the two largest vessels in the world, the "Olympic" and "Titanic." The hulls of these vessels are 882½ ft. long over all. The "Olympic" is expected to be in commission and begin regular trips in June next. The question arises, however, where these monster vessels can be docked.

It is necessary, for safety of course, that a pier should be provided at least as long as the vessel herself. The great new piers which New York City has just completed on the North River near 23d St., however, lack by nearly 100 ft. the length necessary to fulfill this requirement. If the "Olympic" were to be docked at the White Star pier, therefore, her stern would project nearly 100 ft. out into the stream and be subject to risk of injury by passing vessels. The Steamship Co. is therefore asking the New York Harbor Line Board to permit two of the Chelsea piers to be extended out into the North River about 100 ft. to provide berth room for the "Olympic" and her sister vessel.

It is, of course, easily seen that this is only the beginning of such applications. The Hamburg-American Co. has begun work on a vessel which will be about 40 ft. longer than these White Star steamers, and will doubtless be coming forward shortly with an appeal for permission to lengthen its piers in Hoboken. The Cunard Co. also has announced the undertaking of a vessel which will exceed the Hamburg-American boat in length, and the Cunard piers also will then need extension.

There are two questions of moment connected with this application. One is whether it is really for the public interest and the interest of safe navigation that the free navigation width of the North River should be decreased. The other question is whether the overburdened taxpayers of New York City can equitably be asked to shoulder a load of additional bonds for dock extensions simply because two or three steamship companies have built some vessels far larger than anything hitherto attempted.

If these latest marine monsters represented a real advance in economic transportation—if their construction meant cheaper transatlantic freight transportation—it would be easy probably to answer both of these questions in the affirmative. We know of no reason, however, to suppose that these huge vessels really represent any such advance. They are built primarily to furnish the acme of luxury in passenger travel. Instead of representing an advance in economic transportation they probably represent an actual increase in cost. That is to say, taking the year through, it is probable that passengers can be carried with reasonable comfort on vessels of moderate size more cheaply than they can by these latest marine monsters.

It is urged by those who are appealing to have the North River narrowed, and to have New York City undertake the burden of providing these dock extensions, that these vessels will go somewhere else if they cannot be provided with proper pier accommodations at New York. The best answer to this is that there is no other place where they could go. No other city anywhere can furnish a transatlantic passenger traffic sufficient to make these huge vessels pay.

The curious thing is that these steamship companies should undertake to build these huge vessels without knowing beforehand where they could dock them at this end of their voyage. As the companies have put themselves into a dilemma, it would seem to be a good plan to let them find their own way out. At least, if piers must be provided for these new monsters, we see no reason why the companies who own them should not furnish the money.

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Supplementing the studies of Mr. W. F. Martin on rate of flow of water over dams, printed in our issue of Sept. 29, 1910, we reprint on another page a related article by Prof. G. S. Williams, whose work at the Cornell hydraulic laboratory is well known. While Prof. Williams' article was first published before Mr. Martin's, it leads to very similar conclusions, as will be shown. The two articles in conjunction cover a considerable range of dam forms, in a way that will make it possible to compute many of the commoner cases of dam discharge with far greater certainty than heretofore. We have already remarked, at the time Mr. Martin's article appeared, on the growing importance of accurate knowledge of flow over dams.

Prof. Williams' figures are stated to be derived from tests of model dams—large models, though of course much smaller than most dams required in practice. The results of these tests are not given directly, it seems, but were used in compiling a table of coefficients to be applied to a weir formula. This method of presentation rather masks the peculiarities of the hydraulic action. While it may be convenient for practical use, inasmuch as the 3/2-power of the head is easy to compute, yet it does not throw light on the interesting question discussed by Mr. Martin, i. e., whether a natural formula for dam discharge can be found.

It is clear that a formula which requires the use of a table of coefficients is as good as no formula at all; Prof. Williams' table of coefficients would be no larger, but much more convenient, if it were changed to a table of discharges. A formula which contains within itself all the elements of variation is the desideratum. Mr. Martin found such a formula, for the four dams to which his article referred, by changing the exponent of the head from the figure 3/2 as in the weir formula to a slightly different figure, determined from ratings of the individual dam form. The four dams yielded exponents of 1.50, 1.59, 1.65 and 1.77 respectively, indicating a considerable range of variation as well as a marked difference, in the maximum, from the weir exponent 1.5.

We have examined Prof. Williams' table to learn how it agreed with this result. The various heads given in the table were raised to the 3/2 power and then multiplied by the coefficients of the table. Plotting the products on logarithmic paper, it appeared that, for each of the 14 dam forms covered by the table, a straight line covered all the plotted points with sufficient accuracy. Drawing for each set of points the best-fitting straight line, none of the divergences was large enough to throw serious doubt on the applicability of the straight line, i. e., of a formula corresponding to

$$\text{Discharge} = \text{Constant} \times (\text{head})^n.$$

The exponent $n$ being equal to the slope of the logarithmically-plotted line, it was easily found from the chart, giving, in the order of Prof. Williams' table, the following approximate values:

| | |
|---|---|
| Rectangular dams, | |
| No. 1 | 1.55 |
| No. 2 | 1.60 |
| No. 3 | 1.58 |
| No. 4 | 1.50 |
| No. 5 | 1.50 |
| No. 6 | 1.50 |
| No. 7 | 1.50 |
| No. 8 | 1.50 |
| Triangular dams, | |
| No. 1 | 1.505 |
| No. 2 | 1.505 |
| Curved dams, | |
| I | 1.54 |
| J | 1.58 |
| K | 1.60 |
| L | 1.56 |

These values are all within the range of the four found by Mr. Martin. Together with them they are of interest in giving reason to hope that it may be possible from a full experimental study of dam forms to determine a limited list of discharge formulas covering the more important dam forms in practice. It should be remarked, however, that only moderate heads have been experimented with, so far, and future work must include both very low and very high heads, in order that the limits of application of the simple formula may become apparent.

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A steam engine 56 years old, still in service and doing heavier work than in its early days! This in itself is a remarkable record, but other features make it still more remarkable. Built in 1854 as a simple engine to work on 30 lbs. steam pressure, it was compounded in 1898, and the pressure increased to 120 lbs. In 1910 it was converted into a triple-expansion engine, and now works on steam at 200 lbs. pressure superheated to 430°. By these changes the ancient engine, which might be supposed to have earned the right to rest in a museum, has been keyed up to meet the increasing demands of the plant and the developments in steam engineering. So far from feeling worn out, only a few years ago the engine "ran away" and reached such speed as to burst the rope-drive pulleys, although the engine itself was none the worse for this performance.

This remarkable engine, which has been in continuous service at an English ironworks since 1854, is of the old walking-beam type, having a main cylinder 4 × 8 ft. and built for a speed of 14 revolutions per minute. Its connecting rod is of timber, shod with iron, and its crank shaft carries a large spur wheel gearing with a pinion on the shaft of the main driving pulley. Some further particulars of the changes which this old engine has undergone are given elsewhere in this issue. Unfortunately the name of the original builder is not recorded.

The specially remarkable thing is that the engine built under the shop conditions of 1854 was so well designed and built as to stand these changes, while estimates showed that it was more economical to make these changes than to purchase a new engine. It is interesting to consider the wonderful developments in machine work, engine building and steam engineering that have taken place during the lifetime of this old beam engine. We say "old" because it certainly is old as far as length of life is concerned; but it may be that it has only reached its prime, for the English journal from which we take our information states that there does not appear to be any reason why the engine should not continue to work satisfactorily for another half century.

American engineers and engine builders are frequently accused by their European brethren of building machines to wear out rapidly and be replaced by those of improved design. While the general statement goes beyond the facts we have to admit our doubt whether America can approach this long British record of 56 years, with its compounding and tripling record in addition.

Every reader of the daily press is familiar with the tales of enormous returns to the inventors of such a simple article as the rubber tip for pencils, or the nerve-wracking puzzle of the "pigs in clover" variety, while he who first conceives the really worth while things of earth must struggle against the superior business acuteness of his promoting associates to gain even a livelihood. Such readers as have felt the injustice of this rarely varying rule will be glad, we are sure, to find that justice has at last claimed her own and has rewarded in full measure an original student in a field of true endeavor.

We have seen this newspaper note, like Kipling's item on the expensiveness of the man-eating tiger, start on its modest way from the inside columns of a Pacific coast daily, grow to half-column size on the first page of the wheat-belt journals and finally blossom into full glory as the half-page feature story in the Sunday magazine section of one of our nationally read New York papers. Reduced to its lowest terms the note is as follows; the italics are ours:

> By the recent signing of a contract in San Francisco, George Gates, a struggling inventor of San José, Cal., will become a multi-millionaire through the sale to a syndicate of eleven of the greatest railway systems of the United States of his patent rights to a concrete railroad tie which he has invented. *The price to be paid for the new tie, as reported by principals in the transaction, is* $17,500,000.

For the benefit of the many other workers in the same field and the patentees of numerous similar devices we will also include the secret of the success of Mr. Gates, as told by his appreciative newspaper biographer:

> One day about two years ago Gates was leaning against a barbed-wire fence. He was almost at the last ditch. His meager funds were almost gone. He was almost ready to give up, but the barb wires suggested a means whereby he could reinforce the concrete. "I will just cast some of these barbed wires in the concrete," he thought. It was a happy thought and one that afterward proved to be worth millions.

If for once we may be allowed a hackneyed expression—"It is so simple we wonder no one ever thought of it before." The fictitious Col. Sellers and his "millions" must retire before the strangeness of the truth.

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The Swedish Engineers' Society of Chicago, in printing its annual list of members, has introduced a unique innovation. Opposite the name of each member is printed a miniature portrait ⅞-in. high and ⅝-in. broad. The innovation would be difficult of adoption by one of the national societies, with a membership of several thousand, but for a local society which depends for its success on the cultivation of personal acquaintance among the members, and whose membership is comparatively small, the scheme certainly seems worthy of imitation. If the secretary of any engineering society desires to see what an excellent appearance this members' directory makes with the portraits, we suggest that he write for a copy of the list of members to the Secretary of the Society, Mr. Gustaf A. Akerlind, 3618 Lexington St., Chicago.

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## Water Waste and the General Inefficiency of the Water Department of New York City.

Up-to-date water-works men have long regarded New York City as notoriously backward in nearly everything pertaining to efficient water-works management. Such progress as has been made has been confined chiefly to Brooklyn borough, as an inheritance from ante-consolidation days, or has been brought across the East River by Brooklyn borough officials, promoted to the central office.

Some much-needed reforms were begun a few years ago under the too brief chief-engineership of Mr. N. S. Hill, Jr., but the reactionaries were too powerful or the forces making for reform too inert and Mr. Hill soon went the well-worn path which, sooner or later, all reform officials travel in New York City.

Better things were again promised when Mayor Gaynor came into office, for while a layman was appointed as Commissioner of Water Supply, Gas and Electricity, there was chosen as Deputy Commissioner a man who had made an enviable record for efficiency and able business management as Superintendent of Water-works at Cleveland, Ohio, Mr. E. W. Bemis. But after less than a year of what appears to have been most promising work, Mr. Bemis was forced to tread the well-worn path just mentioned, and with no satisfactory explanation from anyone.

We say no satisfactory explanation, but should perhaps add that statements were made at the time to the general effect that (1) the work under Mr. Bemis could more properly be done under the direction of the chief engineer or the registrar of the department, one or both, and (2) that the work was costing too much.

As to the first of these reasons it is sufficient for present purposes to remark that the work begun by Mr. Bemis was not being done by any one when he came into office; as to the second reason we can state it, we think, in different and more truthful terms. Mr. Bemis's work was costing or was likely to cost too much to the interests which fatten at the expense of the taxpayers.

How archaic and inefficient were some of the methods of the New York water department when Mr. Bemis assumed office, and how great economies he was arranging to put into effect, may be seen by reading the paper by Mr. Bemis, published in this issue. The reader will observe that Mr. Bemis's paper deals only with the technical work accomplished or begun under his direction and contains no reference to his forced resignation from office before his reforms were fully under way.

Of the many evidences of gross inefficiency in the administration of the New York water department which have long been known to water-works men, Mr. Bemis points out two which are particularly bad: soldered instead of screw joints for meter connections and the absence of corporation cocks or shut-off valves on service connections. Either one of these is enough to condemn the administration of any water department, so it is not at all surprising to find that New York, though by far the largest city in the United States, had less than 74,000 water meters in use at the beginning of 1910, and no system worthy of the name for testing and repairing these.

With practically no meters in use one unfamiliar with the slipshod way New York has been governed in the past would expect to find a rigid system of house-to-house inspection to detect water waste and to see that fixture and frontage charges for water were properly assessed; but neither these nor any other efficient means to prevent waste, leaks and stealing of water have ever been put in force by the New York water department.

There is nothing strange or surprising, therefore in the announcement that the Sugar Trust took water from the city's mains for years without paying anything therefor, unless it is that the theft was ever discovered, made public and punished. The discovery of the theft, if we are not mistaken, was due to waste-detection work on a large scale undertaken with fruitful results some years ago, but largely or wholly discontinued soon afterwards. Had this and other measures against water stealing and waste been extended over the whole city and carried out for the past ten years, millions of dollars might have been saved to the city.

It looks very much as if nothing short of an earthquake in the New York water department would be sufficient to dislodge the inefficiency and almost criminal wastefulness which, with brief spasmodic exceptions, has prevailed there, lo these many years. Archaic appliances and methods are still standard; waste goes on practically unchecked; inefficiency runs riot through the whole department.

Occasionally, say once in five to ten years, some official arouses himself and risks his official life by making some effort toward reform. But when such a phenomenon does appear he is either allowed to batter his head helplessly against the adamantine apathy of some somnolent superior officer or else his head is quickly and neatly removed by the political guillotine. We venture to suggest that the Water Department might well be put under the Department of Charities. That is the proper place for asylums.

## Reducing the Cost of Broken Stone.

It would be difficult to overestimate the economic and engineering importance of the article which we publish in this issue describing the new stone crushing plant of the Tomkins Cove Stone Co. It is important because it points the way to a great reduction in the cost of crushed stone; and crushed stone is one of the most largely used raw materials in a wide range of engineering works. For railway ballast and for macadam road construction the consumption of crushed stone is increasing by leaps and bounds. In making concrete, crushed stone is the largest ingredient. If a way can be found by which crushed stone can be produced at a half or a third of its present cost, there should inevitably result an enormous increase in its consumption.

Nothing could more effectively stimulate the construction of improved highways, roads and streets, the betterment of railway tracks and the increased use of concrete in a thousand different lines of construction than a radical reduction in the cost of crushed stone. Such a reduction in cost, moreover, would without doubt open up many new applications and uses of the material.

We believe the Tomkins Cove plant points the way by which such a reduction in the cost of crushed stone may be effected.

From one point of view, indeed, the Tomkins Cove plant is not a novelty. It is to a large extent a reproduction of the ore crushing plant developed by Mr. Thos. A. Edison a dozen years ago and installed by him at the Ogden iron mines in New Jersey. The unfortunate failure of the Ogden plant to attain commercial success as an iron ore producer, on account of the development of the Mesaba iron ore deposits about that time, has caused Mr. Edison's mechanical achievements in the Ogden plant to be generally overlooked. Many of Mr. Edison's friends, however, consider that the Ogden plant ranks among his greatest achievements in engineering.

It is probably well known that it was the failure of the Ogden plant which led Mr. Edison to go into the cement industry in order to utilize there the novel machinery which he had originated to handle the Ogden iron ore.

A good deal is heard nowadays about the application of the principles of scientific management to production. One of the first principles of scientific management is to find out what each step in the process of production costs and then concentrate efforts for cost reduction upon those steps in the process which involve greatest cost.

Now, in the production of crushed stone, it is true in almost every case that the cost of the crushing is by far the smallest item. The big item is quarrying the rock, reducing it to a size which the crusher can take and bringing it to the crusher. The trouble with almost all the rock crushing plants in operation is that the crushers in use will not take in large pieces. This means that the rock after blasting must be broken up by dobying or by sledging or work with plug and feather until it is in pieces small enough to go into the crusher. All this involves hard labor and expense.

Within the past few years the demand for crushers which can handle large pieces of rock has led to the construction of some gyratory crushers of enormous size. Even the largest of these, however, will not take in as big rocks as are treated with apparent ease by the Edison crushing rolls installed at Tomkins Cove.

While the enormous crusher, with its ability to deal with large pieces of rock, is an important and necessary element of economical crushed stone production, it is after all only one element. The first step in the productive process is the blasting. Here the churn drill, with its deep holes and large charges, has displaced the ordinary compressed air rock drill. Experience on heavy railroad construction and on the Panama Canal has shown that blasting can be carried on with churn drills and the exploding of a considerable number of holes at one time with a great saving in the cost of drilling and of explosives per cubic yard of rock broken up. Still more important is the fact that these large charges, buried deeply in the rock, are effective

in breaking up and shattering the whole mass, leaving comparatively few pieces so large that they have to be blasted again before they can be handled by the steam shovel.

The next step is the excavation of the broken rock by large size power shovels able to handle pieces up to ten tons or more in weight. It is necessary for continuous working that two power shovels be provided; otherwise the entire plant would have to be shut down while one shovel was out of commission for repairs. This means, of course, that the plant must be of very large capacity in order to permit working the power shovels at an economical rate of output.

The power shovel discharges its load into a skip which is carried on a special steel car, and both car and skip are particularly designed to stand the heavy battering which they are apt to receive in loading and unloading.

The broken rock, after its passage through successive sets of rolls, is passed over screens where it is graded according to size, and is then discharged either to storage bins, to railway cars or to barges.

At no point, from the time the drill is started in the ledge until the finished stone is resting in the car or boat ready to start on its journey, is human muscle required, either to effect the pulverizing or the sorting of the broken rock or to move it forward on its journey through the plant. The rock moves either by gravity through chutes, or is carried by continuous pan or belt conveyors.

The contrast between a plant operated in this manner and the average stone crushing plant will be apparent to almost any of our readers. It will be evident also to almost any one familiar with the cost sheets of the average rock crushing plant that the Tomkins Cove plant can produce crushed rock for a very small fraction of the cost at the ordinary plant, with its large force of laborers and heavy pay-roll.

We regret that it is not practicable at present to make public detailed figures of the cost of production in the Tomkins Cove plant. We risk little in saying, however, that crushed stone can be produced there, when the plant is operated at its full capacity, at a cost per ton, including interest and depreciation charges, which will not be more than one-fourth the cost prevailing in the average stone crushing plant. In fact, the probabilities are that the fraction will be considerably smaller.

It may be said that there are comparatively few locations in the country where a sufficient market for crushed stone exists to permit the operation of a plant on so large a scale; and manifestly, unless a plant can be operated with a large output, the economies possible with the Tomkins Cove plant cannot be attained. We are by no means certain, however, that this is the case. As we remarked above, the market for crushed stone is all the time broadening. If it can be produced and sold for 25 to 40 cts. a ton instead of $1, the amount which can be used in a given district would probably be multiplied several times over.

Closely connected with the matter of possible output from a plant, is the question of transportation rates. The Tomkins Cove plant is fortunate in having not only rail transportation but water transportation at its door, and in being also within some 40 miles of New York City, with its almost limitless market. There are few or no places where such conditions could be exactly duplicated. On the other hand, there are many places in the vicinity of our larger cities where the possible market in sight would seem to justify the development of a crushed stone plant on nearly or quite as large a scale as that at Tomkins Cove.

In our issue of Oct. 21, 1909, we illustrated a very large stone crushing plant recently put in operation in the vicinity of Chicago, in which many of the elements of economic production which we have outlined above, had been introduced. There are, we believe, opportunities for similar plants in the neighborhood of other large cities.

As we have stated above, the radius within which any such plant can market its product will depend very closely upon the freight rates which it can obtain. Assuming proper siding facilities and the carriage of stone in hopper-bottom steel cars of 100,000 lbs. capacity, it should be possible for a railway to haul crushed stone profitably at a freight rate of not more than 3 to 4 mills per ton mile. If we assume the lower figure, crushed stone sold for, say, 40 cts. per ton at the quarry could be carried 100 miles by rail and delivered at a final cost of 70 cts. per ton.

Of course, if ordinary methods of handling and hauling are in use from the point where the stone is received to the point where it is used, the final cost of the stone in the work will still be excessive. But when the quarrymen and the railway have done their part in laying down crushed stone at a low price, it will then be in order for the contractors or others who use the stone to provide economical methods for receiving and handling it.

It would be a simple matter to build a bin underneath a railway siding into which the contents of a hopper-bottom car of stone could be dumped. A conveyor from this bin could raise the stone to elevated pockets, from which wagons could be loaded by gravity. In the hauling, moreover, by using a motor truck with a capacity of two to four tons, hauling one or more trailers, a great saving should be possible over the usual cost of 20 cts. per ton mile, or thereabouts, which is usually reached when ordinary methods of hauling stone with horses are used.

The next step, of course, is the introduction of machinery for mixing the broken stone with cement and sand in making concrete, but this change is proceeding at such a rapid rate that there is little need to enlarge upon its advantages. Then comes the carriage of the finished concrete by gravity or by traveling conveyors to its place in the work. These things are actually being done already; and are going to be done to a greater extent in the future. It is quite within the possibilities, therefore, to have stone excavated from a ledge and moved by power-driven machinery, without the aid of human muscle, in all its passages through the crushing plant and over various systems of transportation until it is finally mixed with proper proportions of cement and sand, and deposited in place to harden into concrete.

## LETTERS TO THE EDITOR.

### The Strength of Old Timber; An Instance of Cracking After Long Service.

Sir—I have been greatly interested in the two recent articles discussing the lasting qualities of timber, or the action of timber aged in service but subjected to new strain. While the tests reported seem to indicate greater strength in the old stock, is it not likely that the new stock, tested for comparison with the old, was of a much inferior quality?

I have seen 2-in. white plank, 24 to 30 ins. wide, in long lengths, perfectly clear and sound. Stock like this came from the trees our fathers and grandfathers cut from the "forest primeval." Carpenters who learned their trade fifty years ago tell us there is no such stock now as there was in those days, and these workmen know their trade. One of these men would feel confident the greater strength of the aged timber was only what should be expected, because of its superior quality; and if it had been tested at the time it was put into the bridge, it would have given results as far ahead of the modern sample as the old stock did. There must be some foundation for the universal opinion of these finished woodworkers.

During my twenty years' connection with Lockwood, Greene & Co., Mill Engineers, of Boston, I have on several occasions taken old white pine timbers from mills when making repairs or extensions. I have always found them sound, except in some cases where the ends were built into the walls. Test borings, however, seem to indicate less elasticity than one would like, and in some cases the borings seem lifeless.

About ten years ago I was sent to examine a mill in which some of the floor timbers had recently cracked. It was an old-type Massachusetts cotton mill, 48 × 200 ft. and five stories high, built about 1845. There were the usual narrow bays, low stories, narrow and short windows, trussed roof and no columns in the top story.

The timbers were 10 × 14-in. continuous sticks across the building, and were supported by two rows of columns so spaced as to leave the middle bent about 25% wider than the wall bents. These timbers had been carrying the floor and machinery loads for about 55 years when I saw them. Several of these timbers had cracked near the center of span, vertically from the bottom of the beam, about 4 ins. toward the central axis, the crack opening about 1-16. in. at bottom. It was, of course, somewhat ragged or saw-tooth shaped, but there was in no case any splintering, though in one or two cases a slight longitudinal crack had started from top of vertical crack and extending some 18 to 24 ins. In every case the cracks were as nearly plumb as the average carpenter would cut them with his saw.

I was given the problems: Why did the timbers crack? Will the other timbers crack? Is the mill in any danger, near or remote, of collapse? What will be required to make the mill safe and at what expense?

I had test borings taken from the timbers near the cracks and also from the ends where built into the walls. The dust from these borings showed the wood to be as sound as it was when put into the building, though it had lost some of its elasticity. By rubbing it in the hands it would pulverize to about the size of ordinary sawdust.

I immediately noticed the sag in the floors, and measuring this carefully I found the timbers had sagged from 3¾ ins. to 5 ins. at the center of the 42-ft. width. This was evidently the cause of the cracks; but it was a little mystifying to find the maximum deflection not always at the timber cracking. Crawling under the mill, I carefully examined the foundations, but could detect no indication of settlement of recent date. This led me to the conclusion that a settlement of the column piers had occurred soon after the building was erected, and while the prime white pine stick was comparatively fresh it had sufficient elasticity to withstand the strain due to this excessive deflection; but after 50 years' exposure to the temperatures usually maintained in a cotton mill, the timber had lost so much of its high strength that it snapped at the point of greatest deflection. It is likely the jar of the machinery in operation may have been instrumental in causing failure.

At two different times since then other timbers in the same building have failed in the same manner; and I was called upon for another examination about a year ago.

This experience, together with the general characteristics of a great many borings I have made in old white pine timbers in other mills, leads me to believe it is much safer to use aged stock for purposes where great strength is not required.

Wm. P. Snow.

Auburndale, Mass., Dec. 26, 1910.

[Whether or not the wood obtainable to-day is weaker than the wood of 50 years ago is debatable, though no data on the point have come to our notice. We see no reason to expect that small clear samples would differ in strength from corresponding ones of the prime timber of former days.

Concerning the lack of "life" in old wood, it will be interesting to know what physical property this "life" represents. Certain old woods are sensibly hard to cutting-tools, one might say indurated. Is this the same effect as meant by "lacking life"? If so, does it indicate lower resilience, or merely increased hardness of the fibers?—Ed.]

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Sir: An interesting addition to the discussion started by Mr. C. P. Buchanan in your issue of Dec. 8, 1910, concerning the strength of old timber, may be found in Bulletin 41 of the University of Illinois Experiment Station, entitled "Tests of Timber Beams," by Prof. A. N. Talbot.

Among the series of tests made was one on a set of twelve old Douglas fir stringers which had been removed from a railroad trestle in Nebraska after being in service for eleven years. Their section was approximately 7 × 16 ins. In order to judge of the effect of weathering and service, a set of 16 new Douglas fir sticks of similar dimensions was tested in the same way, *i. e.*, as beams loaded at the third-points on a span of 14 ft. 6 ins. Of those sticks which failed by horizontal shear, the average maximum horizontal shear developed in the old timbers was 298 lbs. per sq. in. while the new sticks averaged 323 lbs. per sq. in. Of the stringers which failed by tension, the maximum average fiber stress was 3,690 lbs. per sq. in. for the old sticks and 4,088 lbs. per sq. in. for the new.

As there is nothing to indicate the quality of the wood in the two cases, or to indicate the amount of the deterioration in the old sticks from their condition when new, the data above given must be used simply as a comparison of old used sticks against timber of the quality now used.

W. R. Robinson.

5531 Monroe Ave., Chicago, Ill., Jan. 2, 1911.

[This comparative test of old and new fir sticks was noted in our original editorial on this subject, in the issue of Aug. 18, 1910.—Ed.]

## Depositing Concrete by Gravity in Chutes.

Sir—In your issue of Dec. 8 there appeared a very interesting article on the method of conveying mixed concrete by means of pipes variously supported. In reading, the question occurred to me, "How do they avoid the rapid, though gradual, accumulation of hardened concrete on the interior surface of the pipe?" Also, "What sizes of pipe are used?"

I would be glad if you would kindly give us, through the columns of your valuable journal, some information on these points.

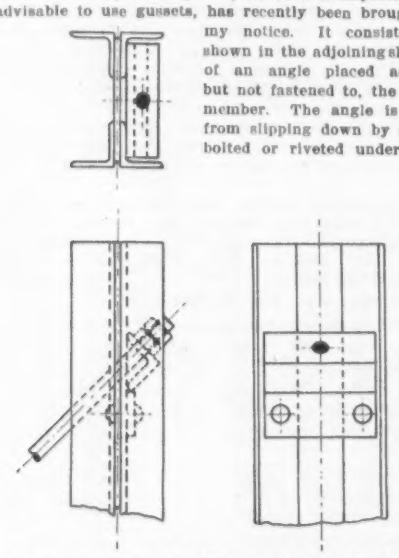
Floyd L. Burr.

Vulcan, Mich., Dec. 16, 1910.

[In answer to the first question, we are informed that there is no trouble from concrete sticking to the surface of the pipe. The pipe is washed out before starting to pour concrete through it, and again after the work is stopped. The pipe is scoured clean by the flow of concrete. When the pipe begins to wear on the under side, it is turned around so as to make the upper side available for wear. As to the second question, the size of pipe varies from 5 to 12 ins., being determined partly by the length of unsupported pipe which must carry its own weight and that of the concrete.—Ed.]

## Economical Device to Take the Place of Cast or Forged Angle Washers.

Sir—A device not generally known, to take the place of cast or forged angle washers used at the connection of lateral or sway bracing rods, where it is impossible or inadvisable to use gussets, has recently been brought to my notice. It consists, as shown in the adjoining sketch, of an angle placed across, but not fastened to, the main member. The angle is kept from slipping down by a bar bolted or riveted under it.



Device to Take the Place of Angle Washers.

It can readily be seen that this device is infinitely cheaper than the ordinary washer, as practically any angle can be used by merely shearing off a part of one leg so as to get the angle to set properly, or, if during erection, it is found that the angle does not set just right, it can be hit a blow by a sledge and adjusted to suit conditions.

F. R. Steuart.

Steelton, Pa., Dec. 5, 1910.

## Cracks in Concrete Building Under Test No Sign of Poor Construction.

Sir: The writer has been informed that the fact that cracks were developed in the test of a reinforced-concrete building for actual stresses, described in your issue of Dec. 22, 1910, p. 697, has been used by certain parties to mislead prospective builders as to the results of the test. I wish to repeat the statement made in the article referred to above, that all the cracks observed in this building were of a very faint, hair-like character such as must necessarily appear in any reinforced-concrete structure when the stress in the steel reaches 5,000 to 10,000 lbs. per sq. in. Similar cracks may be observed in every properly designed reinforced-concrete structure when loaded, and their presence is in no wise an indication of improper design. As was stated in the account of the test, cracks are exceedingly easy *not* to find, and the fact that they are not ordinarily reported in building tests is probably due to two chief causes: first, they are not ordinarily sought after with very great eagerness or with proper aids to the sight; and second, the position of the load is frequently such as to conceal the more noticeable crack formations.

It is a matter of regret to the writer that a test of this character should be willfully misinterpreted, especially in view of the fact that we must look to engineers and contractors for cooperation in making more such tests. The progressive designers and erectors of the building tested at Minneapolis bore the greater part of the expense of the test, and showed the confidence in their construction to submit it to test by a public institution like the University of Illinois Engineering Experiment Station. In justice to them it should be stated that the test showed a well balanced design for the floor slab tested.

Arthur R. Lord.

Engineering Experiment Station, University of Illinois, Jan. 3, 1911.

## The Ownership of Removed Material.

Sir: Referring to the question as to ownership of materials to be removed on old work, which is raised in your issue of Dec. 22, 1910, I would like to say that this is a question which has come frequently to my attention. In common with the majority of engineers it has been my lot to work at times for an owner and deal as his representative with contractors, and I have also been employed by contractors as a superintendent. The idea I find is common with contractors that ownership of old materials lies in the hand that removes them. The theory is that when the site is turned over to the contractor it is abandoned temporarily by the owner. I have heard well-known contractors state gravely that if they discovered a pot full of precious jewels and gold on the site, it would be their property.

As a fact the materials belong to the owner, in the absence of a stipulation otherwise in the contract. The contractor must remove the old materials to a point merely where they will not be in his way in the prosecution of his work. If compelled to carry them farther he can rightfully charge the owner for the expense of so doing, or can call upon the owner to remove them. To prevent disputes, the disposal of old materials should be always provided for in the contract.

Yours truly,

Ernest McCullough.

Fisher Bldg., Chicago, Ill., Dec. 27, 1910.

## The Imhoff Sewage Tank: A Disclaimer.

Sir: It has just come to my notice that some persons have expressed the supposition that I had some other than a purely professional interest in the Imhoff tank because I have recently on several occasions called attention to it and advocated it for the separation of the coarse suspended matter from sewage and for the treatment of the deposited sludge.

I hope you will permit me through your columns at once to disabuse the minds of such persons, by emphatically denying any basis for such a presumption and stating that I have not and never will have any commercial interest directly or indirectly in any apparatus or process forming a part of any work which, as a consulting engineer, I have recommended or may recommend to public or private clients.

Since my last return from Europe it is true that I have repeatedly called special attention to the Imhoff tank. But this was done because I now consider it to form one of the most important and useful steps of progress in sewage treatment we have made for a number of years, and because I desired that my own country, where so many cities and towns can be benefited by it, should enjoy its advantages as soon as possible. My interest is purely and solely a professional one, and my communications have been made frequent partly by invitation and partly to advance the subject more rapidly than might otherwise have been the case.

It may be proper to add a few words as to what my relation has been to the sewage sludge question, since the time when in 1880 I first studied it in England. At that time and up to the present, as everyone knows, the sludge disposal has been the most troublesome feature of sewage works, wherever it was necessary to separate the gross suspended matter from the sewage. The trouble was due to the nuisance created by the offensive odors at the place of treatment and to the difficulty of quickly drying the sludge for permanent disposal.

One proposition after another failed to prevent the usual foul odors, and with the advent of the septic tank these had practically become to be considered a "sine qua non"; a wide belt of land being generally reserved around the works to secure immunity from the nuisance. Such a condition never appealed to me as a final one and I considered that the question of sludge treatment still remained the most pressing one for solution. I was, therefore, on the constant lookout for any favorable progress in that direction.

What appeared to me the most promising work in this direction was that of Dr. W. O. Travis, of Hampton, south of London, England, who was separating into two compartments by gravity most of the suspended from the liquid matter, and who deserves a large share of the credit in this modern movement. I then became acquainted with Mr. Wattenberg, Engineer of the Emscher district in Germany, a few years before his death, who was studying the Travis tank with reference to its introduction in his district.

During that study, Dr. Imhoff, then also an engineer of the Emscher district, discovered certain facts which made it possible to improve upon the Travis tank, and not only to get a sludge decomposition which was inoffensive, but a sludge that would dry quickly and allow of a non-odorous and economical removal and disposal.

These promising discoveries, after the unsuccessful efforts of many years in both America and Europe, were one of the causes for making a trip to Europe in 1908 to witness the actual conditions and results. Apparently these were satisfactory, but the experience had been so short that I was not yet entirely sure of a permanent success, and intended to make another visit two years later, which was last summer.

After returning home in 1908 my hopeful anticipations were not shared by most of those with whom I spoke, and naturally my assurance was not increased thereby, the subject being more of a chemical and bacteriological than an engineering one.

Fortunately, the Engineering Department of Philadelphia, through its Chief Engineer, Mr. George S. Webster, determined to erect a small Imhoff tank and to get experience data regarding the process under American conditions. The results after nearly a year's trial was confirmatory of those obtained in Europe. Meanwhile, conversations with Dr. Imhoff, during his visit to America in 1909, and further European correspondence and publications, proved that no serious difficulties were appearing.

Last summer I again visited a number of such plants in Germany and without exception found them inodorous, and yielding quickly-drying sludge, without incipient troubles of any kind. There were then already over 25 plants in operation.

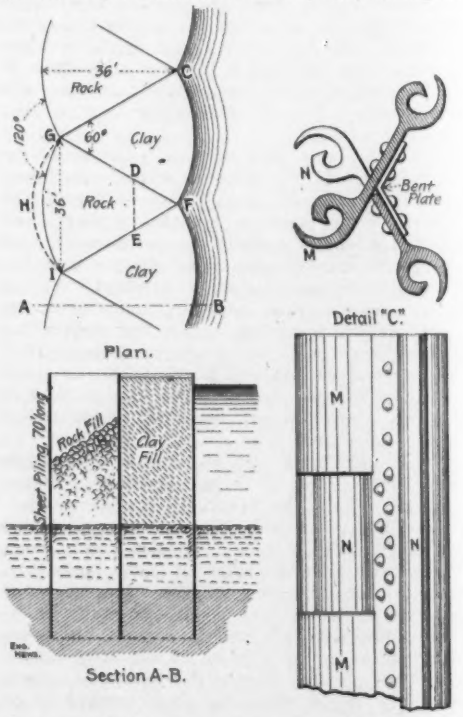
Therefore, as all my own doubts had been removed regarding a large sphere of usefulness for these tanks (whatever modifications might later be found advisable under some special conditions) and as I learned that the royalty charge was very small, I felt it to be a duty to my American confreres to call attention to this advance, so that we might keep abreast of the progress which is being made elsewhere.

Rudolph Hering.

170 Broadway, New York City, Jan. 3, 1910.

## Clay Pressures and Steel Cofferdams.

Sir: The recent failure in this city of a steel sheet-pile cofferdam with clay filling in water about 32 ft. deep, before pumping was commenced to un-water the area to be protected, shows the lateral pressure due to clay deposited under water to be substantially the same as estimated in your editorial of Dec. 29, 1910, relating to




Design of Cellular Steel Pile Cofferdam to Resist Heavy Pressures.

the proposed cofferdam for raising the wreck of the "Maine" in Havana Harbor.

Although I believe your estimate of the weight of clay is too high and the percentage of vertical pressure (80%) taken for lateral pressure is too low, the net result corresponds so closely to results observed here that the safety of the proposed "Maine" cofferdam may well be questioned.

In considering a design some months ago for a coffer-

dam for use in the construction of the river section of the La Salle St. tunnel in this city, where the depth of water would at some points be 50 ft., the writer devised the general construction shown on enclosed sketch, with the exception that the dimensions have been roughly adapted to the "Maine" case for comparison.

It will be observed that the dam is divided into practically equilateral triangular cells by cross walls of steel sheet piling, the variation being in the exterior and interior walls which are curved to withstand lateral pressure by tension in the sheeting. The triangle being the elementary form of all bracing and trusses, this form should be as efficient as is possible to produce to take care of inequalities in loading or resistance with sheet piling alone.

Alternate cells are to be filled with clay and broken stone. The advantage of rock-filled cells along the inner walls, having a low active lateral pressure and high passive lateral resistance, between the clay and inner wall will be apparent to all who have occasion to use accepted formulas for the internal pressure in granular material.

With the bent plate used for detail *C* caulked, it will be noted that to pass through the dam water must pass through three sheet-pile walls, while with the cylinder type of construction but one wall is opposed to the flow at the junction of cylinders, and two at other points.

Additional precautions against the passage of water through the dam may be secured by short walls as at *D-E* and filling triangle *D-E-F* with clay.

Additional strength may be secured in many ways depending on conditions and materials.

The curvature of exterior walls may be increased as at *G-H-I*.

The angle (60°) between interior walls may be diminished.

Cables or rods drawn taut as along *C-F-B* in the deepest water and at low levels in similar manner along the interior walls may be used to increase the factor of safety of the curved walls.

Cross walls may be strengthened up to the limit of pulling the outer row of piles by cables or rods attached near the mud line at *C-F*, etc., and to the top of piles at *G-I*, etc., and additional stability secured by ballast applied at *C-F*, etc. All tendency to buckle or "shingle" the piles of cross walls may be prevented by waling timbers along their tops.

For cases other than that shown, another design for detail at *C* should be used.

The steel work for this construction will be about 25% more and the filling about 25% less than that required for the cylinder plan.

J. W. Pearl.

1106 Rookery Building, Chicago, Jan. 3, 1911.

## The Design of Cofferdams for Deep Water.

Sir: The writer has read with deep interest the article concerning "The Army Engineers' Plan for Raising the Wreck of the 'Maine'; The Design of Cofferdams for Very Deep Water," in your issue of Dec. 29. Also the description of this plan in your issue of Oct. 20 last.

In the light of the purposes of this undertaking, the reasons for choosing the cofferdam method for raising the "Maine" are convincing; in spite of the fact that cofferdams are notoriously uncertain in their behavior, even when used for ordinary depths of water, 25 ft. or less; and although it is probably true, as you suggest, that a cofferdam in such a depth of water, on such a bottom, is unprecedented.

This plan is of particular interest to the writer, because in the case of the deepest cofferdam with which he has had to do (one in New York Harbor, 25 × 65 ft. in plan, sunk through water and silt to rock some 50 ft. below) steel interlocking sheet piling driven in a single line around the area to be laid bare and braced from the inside, as the water and silt were removed, proved wholly insufficient. At a depth of about 30 ft., the dam burst apart and the water filled the dam; nor was rock reached until a deck was put on and the remaining distance accomplished under compressed air.

At the time of this experience, the use of cylinders of interlocking steel sheet-piling with an arch connecting adjoining cylinders occurred to the writer as offering the most stable form of cofferdam. And the proposed plan for the "Maine" is, so far as he knows, the furthest advance toward the use of this method. The section of steel piling selected seems best adapted to the purpose, being apparently an advance over the simpler section which was used in the cofferdam built by the writer.

A very serious difficulty in the use of sheet piling of the section shown and probably with the section selected, arises when an old pile or other obstruction of like nature is encountered in somewhat the manner shown in the sketch.

The writer found time and again, on this and other work, that when an old pile was encountered standing at a slight angle to the course of the steel piling, the adjoining steel piles were bulged out and forced gradually apart as they were driven down, the process being so gradual that it could not be detected during the driving. If the old pile was at a considerable angle with the vertical, it could be detected by the difficulty of driving and it was always found possible to remove the obstruction, or to cut through it, but with the obstruction at only a slight angle to the vertical, the steel piles were gradually forced apart at the joint as the driving continued and the damage could only be discovered upon emptying the dam.

In light of the foregoing, it seems entirely possible, to the writer, that some old pile, buried log, or old wreckage might be encountered in driving a cylinder, the obstruction being at such an angle that one or more joints would be forced open as the driving continued without the engineer in charge, no matter how painstaking, being aware of anything wrong.

This should be considered in view of the high tensile strain it will be necessary for the joints to resist, due to the fill used in the cylinders. Further thought might convince one of the wisdom of making the fill in these cylinders self-sustaining by using a suitable aggregate and mixing with it a small amount of cement.

This again would raise the question as to whether the silt already in the cylinders when driven should not be removed before placing the firmer material. And again whether the clay below the silt is stiff enough to sustain the unbalanced pressure due to the great weight of the cylinders with their filling and the vertical component of the pressure, together with the weight of the water outside the dam, when the cofferdam is unwatered. This clay must now be under a pressure of something like a ton and a half per sq. ft. It is proposed to remove the greater part of this pressure from the inside of the dam and to increase the pressure under the cylinders. Will the clay be stiff enough to remain in its present position, or will it raise inside the dam?

These matters, however, must be determined by engineers who have made a study of the conditions on the spot. And the writer aims, not to review the proposed plan, but to call attention to one very insidious difficulty which he has encountered in the use of such piling; with the hope that it may be of some little aid to those responsible for this undertaking, a responsibility which only one who has been in charge of a deep cofferdam will know how to appreciate.

Charles H. Higgins.

15 Exchange Place, Jersey City, N. J., Jan. 4, 1911.

## Mistakes of an Unsuccessful Engineer.

Sir: The article in the Dec. 22 issue of the Engineering News on "Some Mistakes of an Unsuccessful Engineer," by "A Veteran," was very interesting to me. It is not often that an engineer thus shows his human side in print. As one of the younger generation (for with but ten years of practice I consider myself a young engineer), I want to improve my present opportunities so that I may finally call my life a success.

From the outward point of view, it would seem as if this Veteran's life had been fairly successful. He has lived and he has worked; whether his work was appreciated or not, he gives us no reason to believe that he has been false to any of his fellowmen. That, in spite of his so-called "failures," he was able, again and again, to secure good positions is evidence that he had not given up hope. We cannot all be Chief Engineers; some must continue in subordinate positions and it is hardly reasonable to make "Success" synonymous with "Chief Engineer."

It would seem that the Veteran was afflicted with too good a memory and perhaps with a desire for a placid, uneventful life of ease. Every work of any consequence has its unpleasant side; as long as the breed of men we are acquainted with, remains on earth, we may expect differences, bickering and some under-handed dealings. But is it not a part of our duty to face and overcome such obstacles?

Then, too, why say the saddest "of all sad words of tongue or pen," "it might have been." When we change our positions or make a decision, we do it with the idea of securing the best results. That *A* stayed and became Chief Engineer, while *B* left and became a mere foreman is not pertinent. Had the decisions been reversed it is extremely probable that the gains of each man would have been somewhat the same as he received anyway.

I thoroughly believe that as long as a man loves his profession, has fair health and is honest, he is a successful engineer, be he a famous consultant or only an assistant. The unsuccessful engineers have left the profession and are in other lines of work. It is not dollars, nor is it a desire for fame that makes us engineers. It is because we love a work of the most exacting kind in the most scientific profession of to-day.

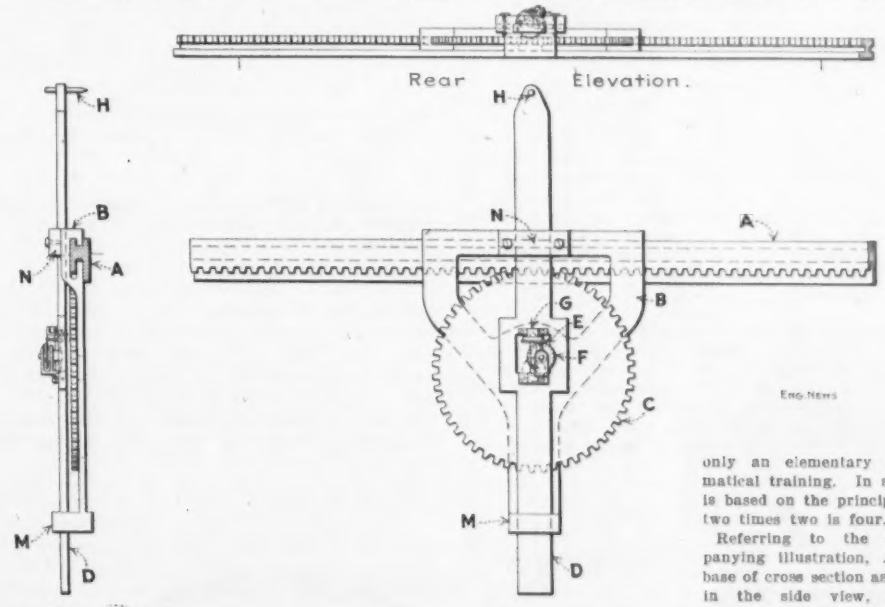
Yours in Engineering,

H. B. H.

Dec 27, 1910.

## An Easily Understood Planimeter.

Sir: I am sending you herewith a drawing and description of a planimeter designed by the writer. While admittedly less convenient in practice than other planimeters now in use, this one is of some interest because of the simplicity of the principle on which it works. Its principle does not involve the higher mathematics and can therefore be understood readily even by those with only an elementary mathematical training. In short it is based on the principle that two times two is four.




AN EASILY UNDERSTOOD PLANIMETER.

Referring to the accompanying illustration, A is a base of cross section as shown in the side view, having two wide flanges connected by a short web. It is supported on two pins which hold it in place on the paper when in use. The rear edge of the upper flange is toothed to form a rack. B is a frame or carriage with projections sliding in the grooves of the base A. C is a circular toothed disk pivoted at its center to the carriage B and meshing with the rack on A.

D is a bar of rectangular section and is a close sliding fit in the slots M and N in the carriage B. The bar D carries the small graduated wheel E whose flange is in frictional contact with the disk C. Revolutions of E are recorded by the counter F and a vernier G is provided to give close readings of the scale on the rim of wheel E. When the carriage is slid along the base, the toothed disk revolves and transmits its motion to the graduated wheel.

By sliding the bar D in its guides M and N, the wheel E can be moved back and forth along a diameter of the toothed disk. When the bar is stopped with the wheel over the center of the disk, no motion of the wheel will result no matter how much the disk revolves. If the carriage is now slid along the base with the bar D held in this position, the tracing point H at the end of the bar will draw a line parallel to the base. This is the "zero line."

Supposing now that H is moved along any other line, the wheel E will at any point have a motion directly proportional to its distance from the center of the toothed disk. The motion of E will therefore be proportional to the area between the zero line and the line traversed by the tracing point H. The small wheel is so graduated that this area can be read directly.

When the figure, whose area is to be found lies above the zero line, the tracer in going along the remoter side records the area between it and the zero line. In going back along the nearer side, owing to the backward motion of the wheel, it subtracts the area between the nearer side and the zero line from the area first recorded. The resultant area recorded is therefore the actual area of the figure. When the figure, whose area is to be found, lies both above and below the zero line, the tracer in going along the side above the zero line records the area between it and the zero line. In going back along the side below the zero line the recording wheel E is on the other side of the center of disk C and its direction of rotation is consequently unchanged. It therefore adds the area between the lower side and the zero line to the first area, and the resultant area recorded is again the actual area of the figure.

S. G. Zuckerman.

1006 Grand Central Station, New York City, Nov. 23, 1910.

## Hardpan.

Sir: Referring to the letter "Foundation Pressure on Hardpan" in your issue of Dec. 29, 1910, I will suggest that no dependence should be placed in hardpan without actual proof (by borings) of thickness of strata and character of underlying formation. A mere cap may be and has been taken for ample foundation, which later proved to cover a stratum of very soft clay. This is giving hardpan the meaning accepted by various Canadian engineers, viz., an intermediate between shale and slate. I offer this only as a reminder.

C. M. Lawrence.

Holdenville, Okla., Jan. 3, 1911.

## Notes and Queries.

In the article entitled "Dams, Barrages and Weirs on Porous Foundations," by Mr. W. G. Bligh, published in our issue of Dec. 29, 1910, p. 708, we regret to state that the references in the text to the figures illustrating the article were misstated, owing to the omission of a figure which it was originally intended to include. As a result, all references in the text to Figs. 6-13, respectively, should be to Figs. 5-12, respectively. Further, the cuts over the captions Figs. 7 and 8 were interchanged. On account of this confusion we have had a number of corrected reprints made of the article and any subscriber who wishes to replace the original text with the article correctly printed may obtain a reprint by writing the author, Mr. W. G. Bligh, 44 Dupont St., Toronto, Ont., or to this office.

Attention is directed to the omission of a $\pm s$ in the letter of Mr. A. L. Menzin, "The Physical Meaning of Entropy Defended," as printed in some copies of our issue of Dec. 29, 1910. The error occurs in the sixth integral expression on p. 729 and was caused by the breaking of type in the press. The continuity of the argument, however, is evident on careful reading.

## Rebuilding the LaSalle St. Tunnel Under the Chicago River.

The LaSalle St. tunnel under the Chicago River, at Chicago, is the third street railway tunnel (of the Chicago Railways Co.) which has been rebuilt at a lower elevation to permit the deepening of the river as demanded by navigation interests. The Van Buren St. tunnel is complete

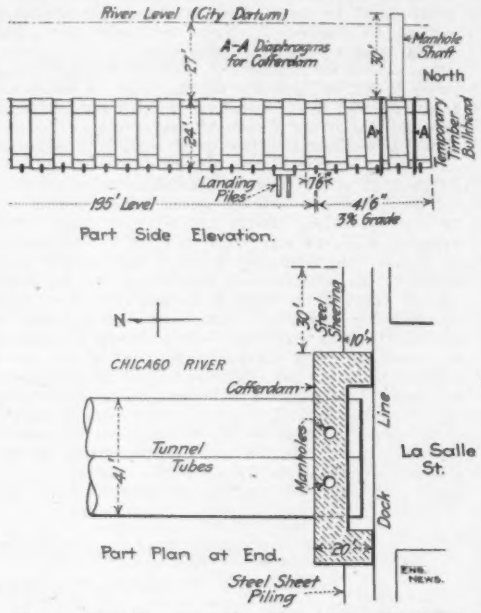



Fig. 1. Part Plan and Elevation of the Steel-Tube River Section of the LaSalle St. Tunnel, Chicago.

and open to traffic. The Washington St. tunnel reconstruction is nearly completed and a description of it was published in our issue of July 21, 1910. The LaSalle St. tunnel is of special interest on account of the method adopted for building the river section. This section was built in a single piece as a twin-tube shell of steel and concrete, which was then sunk in a trench dredged to receive it. The width of the river on the center line of the tunnel is 278.2 ft.

In the preliminary studies by the Board of Supervising Engineers (which has charge of all the street railway reconstruction work) six designs were made: (1) and (2) a double track rectangular tunnel with flat roof of I-beams and concrete, and double track brick or concrete tunnels for the approaches; (3) and (4) two tunnels of brick and of reinforced concrete; (5) a triple-tube concrete tunnel, and (6) a triple-tube steel shell for the river section and triple-tube land tunnels. The steel shell design was based upon that of the twin-tube Detroit tunnel. The triple-tunnel designs were to provide for carrying various pipes and conduits across the river, but the cost due to such construction was found to be so great that these utilities were accommodated in a separate tunnel, as described later. After a consideration of the plans the Board of Supervising Engineers selected the design for a twin-bore reinforced-concrete tunnel, and the contract was let on the basis of this design. One reason for adopting the twin-bore type was to obtain a certain element of ventilation due to the passage of the cars.

### River Section.

It had been assumed that the construction of the river section of the tunnel would be done as open-cut work in temporary cofferdams, obstructing only a portion of the river channel at one time. The U. S. government engineers, however, would permit cofferdams only for a distance of 60 ft. from the dock line (on one side at a time), and refused to permit obstruction of the remaining 180 ft. of the river. The cofferdam method, therefore, had to be abandoned. The location of the tunnel upon the lines and grades desired required the removal of the masonry invert of the old tunnel with its cable conduits (lying under debris of the old roof which had been removed by blasting); it required also the construction of the new tunnel with its roof at an elevation above the old invert. Under these conditions, the use of ordinary methods of tunneling by drifts or shields was impracticable.

In a statement prepared by the Board of Supervising Engineers, and supplementing the original contract, it is stated that after the contract was awarded, representatives of the contractor presented sketches for a twin-bore steel tube for the river portion of the tunnel, these sketches being very similar to a design developed by the chief engineer (Mr. Bion J. Arnold) late in 1908. The contractor was instructed to complete the design and submit it for consideration.

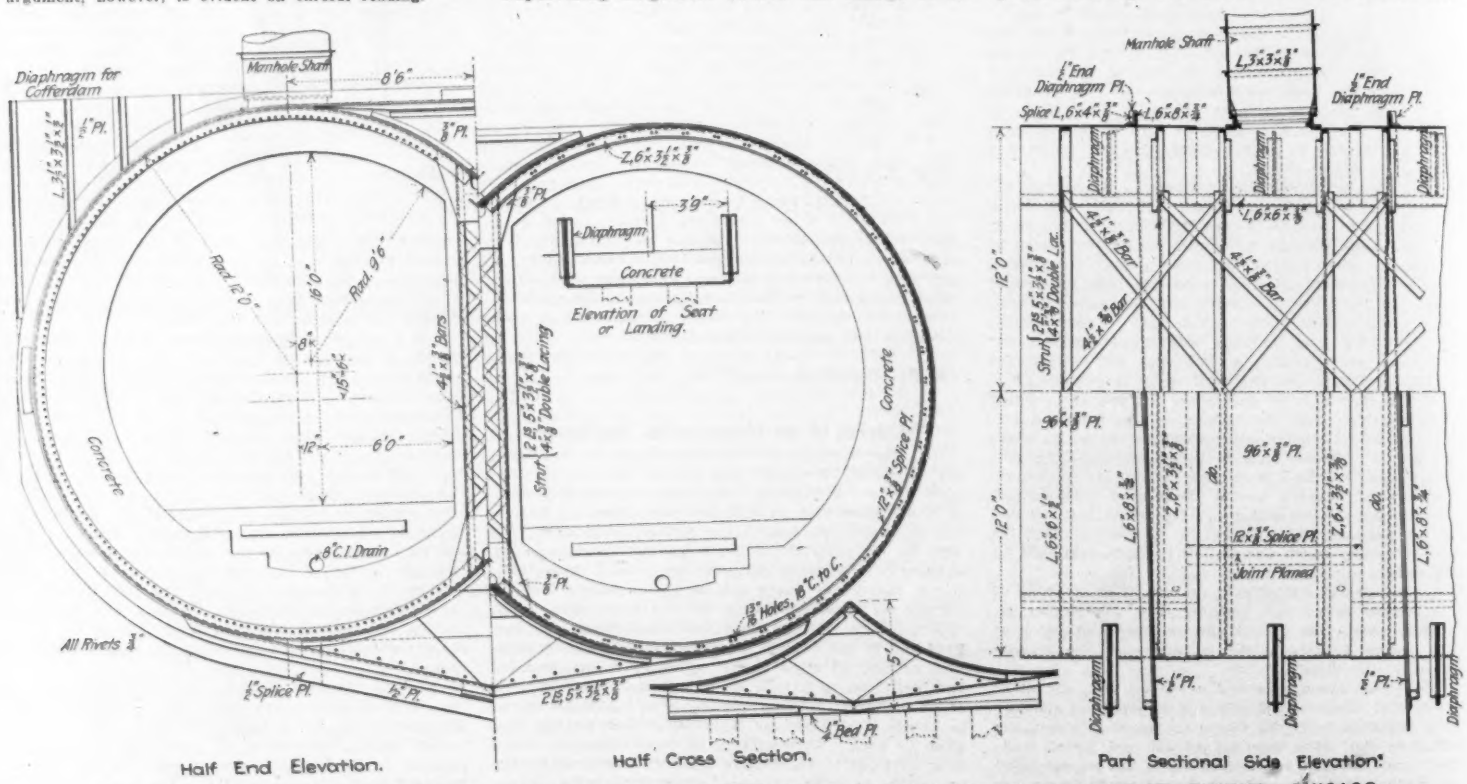



FIG. 2. DETAILS OF STEEL TWIN-TUBE SHELL FOR THE CHICAGO RIVER CROSSING OF THE LASALLE ST. TUNNEL; CHICAGO.

The general scheme for work by this method was to build a steel tunnel shell at some convenient place; then to float it and tow it to the site, to be sunk in a trench dredged in the river bed to the desired depth. Definite plans for this

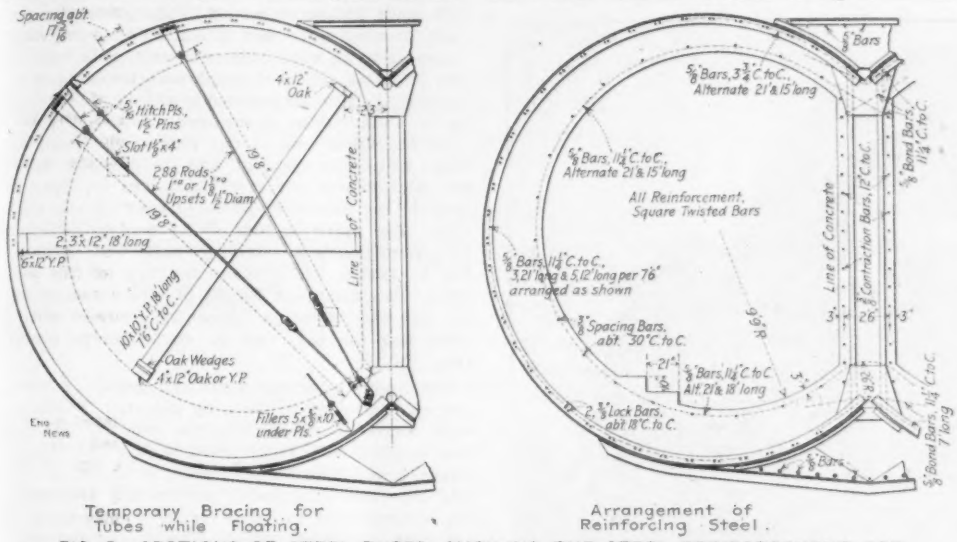

Spacing abt. 17'2"
4"x12" Oak
5/8" Hitch Pls., 1½" Pins
Slot 1⅛"x4"
288 Rods 1" or 1⅛" Upsets 1¼" Diam.
19'-9"
2, 3"x12", 18' long
6"x12" Y.P.
10"x10" Y.P. 18' long 16' C. to C.
Oak Wedges 4"x12" Oak or Y.P.
Fillers 5"x5/8"x10" under Pls.
Line of Concrete
23'
Eng. News
Temporary Bracing for Tubes while Floating.
5/8" Bars, 3½" C. to C., Alternate 21' & 15' long
5/8" Bars, 11½" C. to C., Alternate 21' & 15' long
All Reinforcement, Square Twisted Bars
5/8" Bars, 11½" C. to C., 3, 21' long & 5, 12' long per 76' arranged as shown
5/8" Spacing Bars, abt. 30" C. to C.
21'-2"
5/8" Bars, 11½" C. to C. Alt. 21' & 18' long
2, 5/8" Lock Bars, abt. 18" C. to C.
5/8" Bars
5/8" Bond Bars, 11½" C. to C.
Contraction Bars, 12" C. to C.
R 66'
26'
3'
5/8" Bond Bars, 11½" C. to C. 7' long
Arrangement of Reinforcing Steel.

FIG. 3. SECTIONS OF STEEL TUBES, SHOWING THE STEEL REINFORCEMENT FOR THE CONCRETE AND THE TEMPORARY BRACING OF THE TUBES WHILE FLOATING.

work were prepared by the engineers for the contractor, and these differed considerably from the original sketch design. The contractor made an agreement to build the river section in accordance with these plans at a cost not to exceed that originally estimated for doing the work within cofferdams.

Before preparing these definite plans, the engineers considered the methods of construction used by the Metropolitan Ry. for crossing the river Seine at Paris,* and by the Michigan Central Ry. for crossing the Detroit River at Detroit.* The Paris method involved the use of tubes with working chambers beneath, for sinking the tubes by the caisson system, using compressed air. This would have necessitated temporarily closing a large portion of the river channel, which was prohibited by the U. S. Government engineers, as noted above. The Detroit method, owing to the thick exterior covering of concrete, would have required a greater width and depth of excavation (and consequent increase of approach grades), and would have involved greater expense. The plan finally adopted was to build a steel twin-tube shell (with concrete lining) having the tubes separated by a vertical wall which would give longitudinal strength and rigidity. The total thickness at the roof (which is composed only of the concrete lining and steel shell) is only 2 ft. The shell for the Detroit tunnel was practically a rectangular hull, with outside planking on a series of rectangular transverse diaphragms pierced by two steel tubes. The finished tunnel has concrete filled into the entire space outside of the tubes and each tube has an interior lining of concrete, so that the total depth of concrete at the roof is about 6 ft.

In considering the carrying out of the work under this system the contractors' engineers at first thought it advisable to construct twin tunnel tubes in two or three lengths, consisting of steel shells with concrete lining completed except at junctions, which were to be made by divers. But as the cross section to be used was developed, the longitudinal strength afforded by the immense steel and concrete girder, 25 ft. deep and with a web 3 ft. thick, formed by the center wall at the junction of the two tubes, led to the decision to construct the river tunnel (with lining complete) in one piece before placing it in position.

The length of the steel shell is 278 ft., with a width of 41 ft. and a depth of 24 ft. In section it is composed of two parallel steel cylinders (each about 75% of a complete circle), with a central longitudinal dividing wall. The cylinders are 24 ft. diameter, made up of ⅜-in. steel plates, united by 6 × 6-in. angles at the vertical central wall. The shells are also connected and stiffened by plate and angle gussets above and below the central wall at intervals of 7½ ft. in the length. The upper gussets form a horizontal surface, level with the tops of the tubes. At the center of the cross section the lower gussets extend about 18 ins. below the level of the tubes to form inclined surfaces for the filling material to flow against and give a more secure bearing than could be secured if the bottom was horizontal.

On the inside, the shells are stiffened with Z-bar ribs 6 × 3½ × ⅜-ins., at average intervals of 3¾ ft.; these are to maintain the form during construction of the steel work and finally lock the shells securely to the concrete lining. These rings terminate at the center wall where they are riveted to connecting plates of equivalent strength, which in turn are riveted to vertical latticed-angle posts in the center wall. A complete longitudinal quadruple-intersection lattice truss of structural steel is formed by diagonal bars extending from top to bottom of the center wall upon the outer faces of the posts.

The construction of the shell is complicated to some extent by the requirement of a length of 3% grade in each end in order to meet the established grades of the approaches (Fig. 1). It is further complicated by the construction of double diaphragms in vertical planes around the shells near each end to serve as the initial construction for cofferdams required in making connection to the land approach tunnels (Fig. 2). Two heavy angles are riveted across the shell, near each end, to form seats for future cofferdams, in the event of a bridge being built at this site, requiring piers which will straddle the tunnel. Near each end of each tube a manhole is provided to give access to the interior during construction. Temporary steel shafts, 4 ft. diameter and 30 ft. high, detachable at the manhole ring, are provided for use when the tubes are submerged.

The general design of the tunnel is shown in Fig. 1, while Fig. 2 gives the details of its construction. The shell is of regular boiler construction, with double butt-strap longitudinal joints, and alternate inside and outside lap circumferential joints. All joints are double riveted and calked both inside and outside. A circular opening in each shell panel at the bottom, near the central wall, provides for bonding the concrete lining with the exterior concrete in the recess between the tubes. This steel shell is designed to serve as a waterproofing course as well as a form for the concrete lining, but the design does not regard it as being necessary for the strength of the structure. The exterior was given two coats of red-lead paint. The specifications prepared by the Board of Supervising Engineers required the workmanship "to be equal to the best practice in modern steel and boiler works for cylinder bridge piers and water tanks." It will be seen that there is a reinforced concrete lining within the tubes, varying from 20 to 40 ins. thick, while the central concrete wall is 3 ft. thick. The concrete is a 1:2:4 mixture, and is made with a waterproofing cement (as noted below), although the steel shell is regarded as the waterproofing course.

The shell was built complete in a dry dock upon the North Branch of the Chicago River, about one mile from the tunnel site. While in the dock the concrete in the center wall and enclosing the gussets was placed. Temporary cross bracing was introduced at intervals of 7½ ft. throughout the length to maintain the form of the cylinders, and the ends of the tubes were closed with temporary watertight timber bulkheads. These details, and also the arrangement of the steel reinforcing bars, are shown in Figs. 3 and 4. The weight of the shell when floated in this condition was about 3,000 tons. It was removed from the dry dock on Nov. 21 and towed to a wharf near the tunnel, where the depth of water would permit the completion of the interior concreting. This concrete will increase the total floating weight to about 8,000 tons. Fig. 5 shows the tubes under construction, with the diaphragms for one of the cofferdams.

Upon the under side of the shell, at points about 50 ft. from each end, were formed special blocks of concrete with a level bottom (protected by steel plates) to serve as bearings in landing the tubes and adjusting them to the desired alinement and grade. Seats for the tunnel shell will be provided at corresponding locations in the river bed. Between these seats the shell will be supported uniformly by sand pumped into the space beneath it.

Two methods have been proposed for the construction of these supports. The plan proposed by the Board of Supervising Engineers was to provide a foundation of concrete in which would

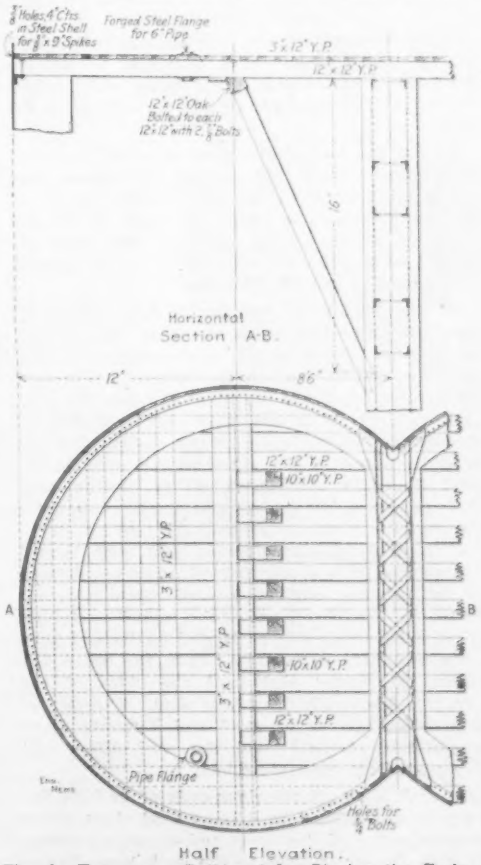



Fig. 4. Temporary Bulkhead for Closing the Ends of the Tubes.

be embedded a layer of I-beams. A second tier of I-beams would be placed crosswise on the first set and brought to a true grade by means of steel shim plates placed by a diver. After the proper grade has been reached these beams would be partially embedded in concrete. This would afford sufficient support for the dead load of the

*Engineering News, Feb. 15, 1906; Oct. 31, 1907; Sept. 24, 1908.

tunnel and allow the remainder of the trench to be filled with sand and give a complete and even bearing for the full length of the tubes. The plan proposed by the engineers for the contractors was to place short piles at the desired elevation, setting them by weights applied instead of by blows; these were assumed to provide landings of known supporting value, which might be lowered, if required, by adding weights to the tubes.

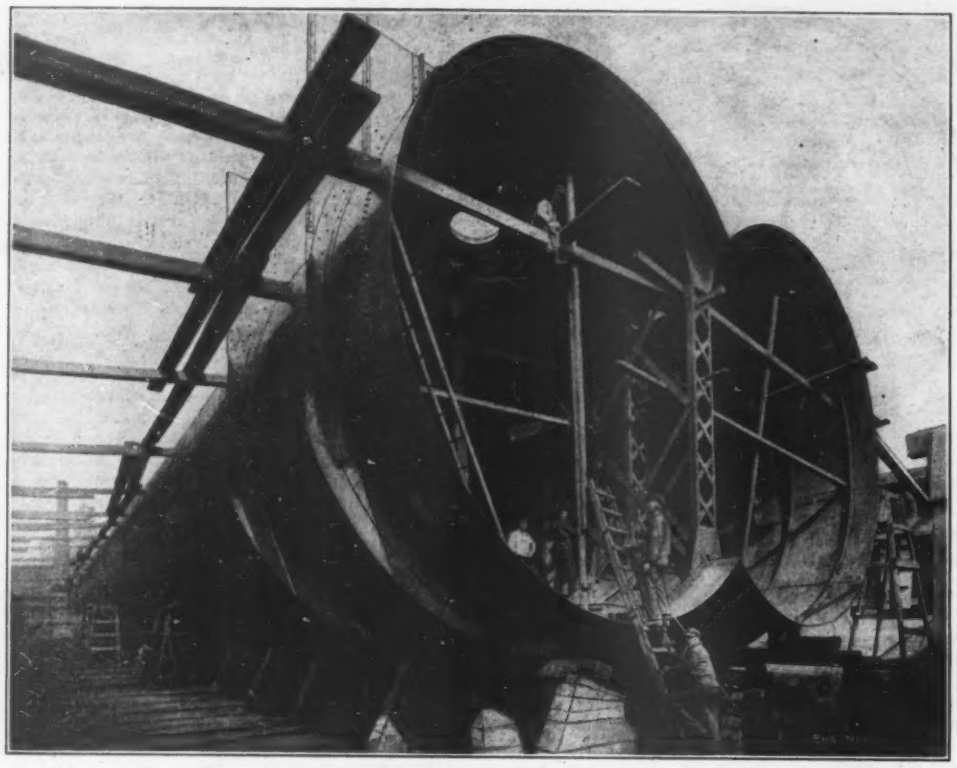


FIG. 5. THE STEEL SHELL FOR THE LA SALLE ST. TUNNEL, UNDER CONSTRUCTION IN A DRY-DOCK AT CHICAGO.

Across the bed of the river a trench was excavated by dipper and clam-shell dredges, care being taken that no material in the bottom of the trench would be above the level of the end supports of the tubes. The dredging was attended with some difficulty, owing to the masses of masonry from the old tunnel.

Within the tubes, transverse dams or partitions were provided at points about 100 ft. from each end. In sinking the tubes, water was admitted to the four end compartments thus formed by means of valves opening through the end bulkheads at the invert level and controlled by stems extended to the top of the shafts. For additional control of the water ballast used in the final stages of placing the tubes, pumps were arranged to empty the compartments or transfer the contents from one compartment to another.

With these sinking devices, and with lateral and vertical lines operated by floating pile drivers or by hoisting engines located upon adjacent docks, the completed twin-tube tunnel (weighing about 8,000 tons) will be landed on its end supports and held in position while the space between the tunnel shell and the sides of the trench is filled with clean lake sand. The central longitudinal girder of steel and concrete gives longitudinal strength, and the sand filling will give a uniform supporting bed.

On each bank, at the river ends of LaSalle St., a recess was formed by driving steel sheet piling across the line of the street and extending parallel with the street lines to the dock line. These recesses or pockets were to receive the end of the tunnel shell when floated and sunk in place. In order to make the connection with the approaches in open cut, a crib cofferdam (channel shaped in plan and shaped to fit over the tubes) will be sunk near each end, fitting between the diaphragms on the tubes. The cofferdam wings will extend to the dock line, and connect with the steel sheeting of the recess mentioned above. This will convert the recess into a pocket, which will be pumped out, exposing the ends of the tubes. The river end of the approach will be built by tunneling behind the cofferdam, so that work on the land tunnel and on the tubes can be prosecuted independently. The depth in these end cofferdams will be about 62 ft.

### Land Tunnels.

The land tunnels or approaches involve special construction in view of the difference between the permanent and temporary track connections. The permanent approaches will be twin-single-track tunnels of reinforced concrete extending from the river to the street-railway subways. The section of these approaches is shown in Fig. 6.

Pending the construction of these subways, however, the approaches must connect with the present surface tracks. This arrangement (shown in Fig. 7) necessitates omitting a portion of the roof of the permanent tunnel in order to carry the temporary grade to the surface. At this part of the work, therefore, the side walls are carried up to the level of a single span arch roof over the temporary tracks. When the subways are built, the center wall and two permanent arches will be built under this roof. To provide for this, iron hooks are embedded in the present concrete roof, from which will be suspended the forms for the future permanent arches beneath it. The rods for bonding the permanent arches to the side walls will be embedded in the latter, the portion intended to project into the arch being bent up so as to be within the wall until such time as the latter is cut away to receive the haunch of the arch. The arrangement will be understood by an examination of the cross section, Fig. 8.

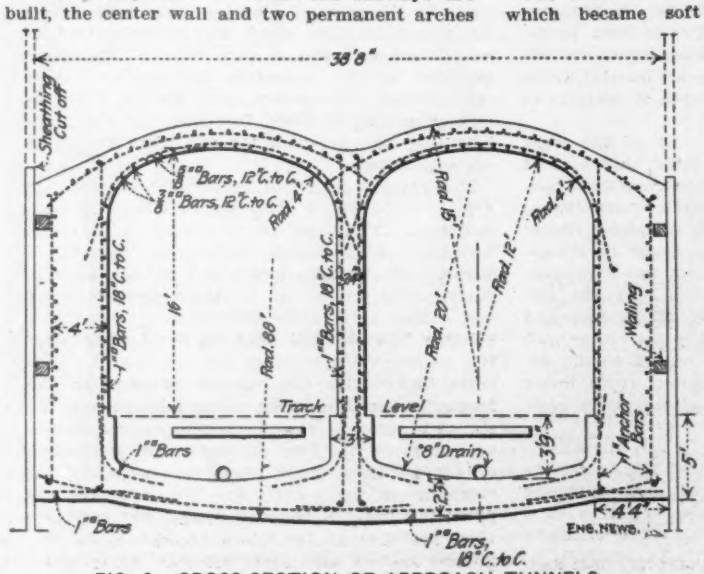



FIG. 6. CROSS-SECTION OF APPROACH TUNNELS.

At the upper end of the temporary approach, there will be an open cut, and the retaining walls are cantilevered out over the tracks in order to provide the necessary width of roadway on each side. The upper section of the wall is designed as an independent retaining wall, with a short toe to anchor the overhanging top of the section. The maximum height of wall is about 40 ft., and the walls are braced by concrete struts (spanning the cut) and by the concrete invert (Fig. 8).

The concrete for the walls and arches in open cut was delivered in place by gravity. The concrete mixer traveled along the side of the cut, and dumped each batch directly into the funnel top of a galvanized iron pipe; the lower end of this pipe had a movable section for delivering the concrete into the wall forms or spreading it out over the arch forms. The steel reinforcement on all the work consisted of twisted square bars. Three separate sizes were used for the walls, arches, etc., so as to avoid the use of the wrong material. Fig. 9 shows the reinforcement in place for the twin-tunnel arches built in open cut. In the middle is the end of the concreting chute or pipe. The concreting was done in sections about 30 ft. long, and the side walls were built in courses about 6 ft. high. This height was just sufficient to clear the next course of timbering, which was not removed until at least three days after the concrete had been deposited beneath it.

The approaches cover approximately two blocks in length on each side of the river. For the block farthest from the river, the work is being done in open cut and for the second block (extending to the river) by tunneling. For the open cut work, steel sheet piling was driven just outside each curb line and to a depth below that of the base of the excavation. As the excavation progressed the piling was braced by heavy transverse timbers about 6 ft. or 8 ft. apart vertically. The timbers of each lower set were supported from the top set by pairs of long rods with straps secured by top and bottom nuts. Posts were placed between the transverse timbers. Between the top and second sets of timbers diagonals were fitted in the end panels, forming transverse trusses to resist the heavy pressure against the piling. This is shown in Fig. 10. Longitudinal timbers between the transverse sets completed the bracing system.

The excavation was in the stiff Chicago clay, which became soft and wet (but still very tenacious or "sticky") in the bottom of the cut. The excavation was done by spades and drawknives. At first the muck was loaded into small end-dump steel cars which were hauled by cable to an elevator. The cage had a tilting floor and the headframe of the elevator was so made that the front end of the floor was held by stops before the hoisting was completed. The final movement of the cage caused the platform to tilt while at the same time the levers of the car door were operated by other stops. The door opened upward and outward, allowing the contents of the tilted car to run out over an apron

into a cart. The tracks had a short up grade to the elevator, and the empty cars were sent down this grade by gravity so that they would run to the end of the track.

Later on, however, dump buckets were used to handle the material. On the south side (from Randolph St. to Lake St.) a rigid runway was used, consisting of a line of I-beams supported on A-frames whose legs were fitted with small wheels. A trolley hoist rode on the I-beams, hoisting and lowering the bucket through the bracing, and carrying it to the end of the conveyor, where it was dumped into carts. On the north side (from Michigan St. to Kinzie St.) a cableway was used.

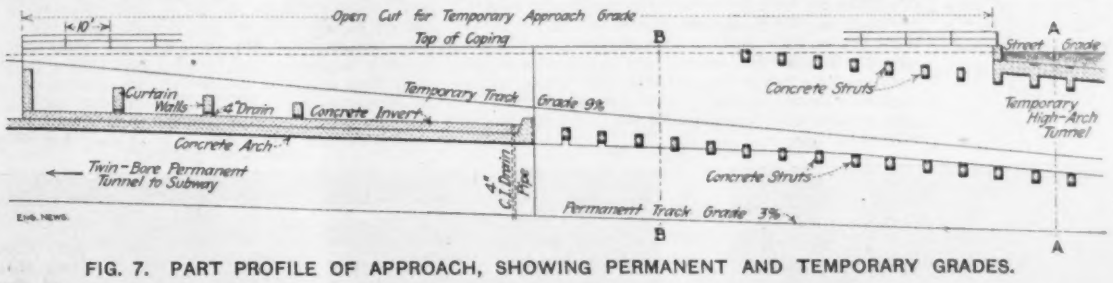



FIG. 7. PART PROFILE OF APPROACH, SHOWING PERMANENT AND TEMPORARY GRADES.

It had been proposed to use the same open cut plan for each block adjacent to the river, but this was objected to very strongly by property owners, on account of the interruption of their business. The contractors then proposed to use a shield, but this would have involved many difficulties, especially as the masonry of the old tunnel lay directly in the path of the work. Thus the shield would have been partly in clay, partly in solid masonry and partly in the open space above the invert of the old tunnel. The Board of Engineers suggested two plans: (1) building the work in open cut, and carrying the street by a flooring on the top bracing of the excavation; (2) tunneling by a central drift method. This latter method had been proposed for the Washington St. tunnel, but afterwards modified by the contractors on that work, who used a side drift on the line of each wall (Engineering News, July 21, 1910).

This plan of a central drift has been adopted for the LaSalle St. tunnel. For each approach, a shaft will be sunk in the street at about 50 ft. from the river, and from this a drift will be driven on the center line of the tunnel with its base at the level of the base of the invert. This will be timbered and will provide for the cars removing material. At intervals of about 30 ft. lateral drifts will be run to the sides of the tunnel; these will be about 10 ft. wide and will provide for the building of a complete 10-ft. section of tunnel. Intermediate lateral drifts will be excavated until a complete series of tunnel sections is formed.

The arrangement of grades is very similar to that of the Washington St. tunnel, described in our issue of July 21. The permanent grades from the river to the elevation of the future street railway subways are 3%. Until the construction of these subways, however, there will be temporary grades of 9% rising from the 3% grades and coming to the surface at Randolph St. on the south and Michigan St. on the north. This makes it necessary to omit a part of the roof of the future approach tunnels, as already described.

### Waterproofihg the Tunnel Concrete.

All the concrete work of the LaSalle St. tunnel is made waterproof by the use of cement containing a special preparation furnished by the McCormick Waterproof Portland Cement Co., of St. Louis, Mo. The basis of the material is an aluminum silicate, which is a dry powder and is added to the cement (any desired brand of cement being used). It is stated that after the cement has been mixed with the sand and stone, and water is added, a colloid is formed, which permeates the entire mass. The material is used in the proportion of about 2.75 lbs. per bag of cement. The plans originally provided for a waterproof course of two layers of brick laid in asphalt, but the contractor was permitted to make the concrete waterproof by the addition of suitable material in the concrete. Different materials or methods were considered and tested, with the result of adopting the McCormick cement. The thickness of the concrete, however, is equal to the originally proposed thickness of the concrete and waterproof course.

Tests of concrete made in this way were made by Mr. L. E. Morris, Testing Engineer of the Chicago Railways Co., and the following particulars are taken from his report. A 1:2:4 mixture was used, the materials being taken at random from piles on the work, and the stone being ¾-in. limestone. Two test pieces were made in 28-in. sheet iron cylinders 28 ins. high. An 8-in. layer of concrete was first placed, and after about 16 hours this was covered with ½-in. of 1:3 grout. A 4-in. tin can 5 ins. high was placed on the concrete, and fresh concrete filled in to the top of the can. After this had been allowed to set for a few hours, the can was removed, and the hollow space covered by a 5-in. plate through which passed a 1¼-in. pipe. Fresh concrete was then filled in to a depth of about 12 ins.

When the concrete cylinders were seven days old, their 1¼-in pipes were connected to the city water mains and a pressure of 22 to 32 lbs. was maintained for six days. A hand pump was then attached, and a pressure of 250 lbs. applied for a few minutes, 200 lbs. for 30 mins., then 250 to 300 lbs. for five mins., and finally 400 lbs. or over. The concrete cylinders showed signs of moisture in five and eight minutes under the heavy pressure, but in both cases the moisture showed only at the upper seam (at the level of the top of the 4 × 5-in. cavity), where the top layer of concrete had been laid upon concrete that had set for five hours, and where no grout had been placed between the layers. When the test cylinders were broken, they showed practically no moisture in the middle layer and none at all in the bottom layer (below the grouted seam). A similar test cylinder made with concrete without waterproofing showed moisture on all sides within a few minutes after water at 35 lbs. pressure was admitted to the pipe. Under a pressure of 120 lbs. (with a hand pump) the water squirted from this cylinder in several places.

Two 6-in. cubes were made having pockets 3¼ × 4¼ ins. to hold water; they were 1¾ ins. thick on the sides and 2¼ ins. on the bottom. After seven days, no moisture appeared on the exterior, and when broken up there were no indications of moisture in the fragments. In the absorption test, four pieces weighing 252 to 358 grains when immersed showed an average gain in weight of 1.55% after seven days. Similar pieces made of concrete without the waterproofing showed an average gain in weight of 6.25% in the same time. Compression tests showed a greater strength for the waterproofed concrete, and this is said to be a general characteristic of the use of the waterproofed cement.

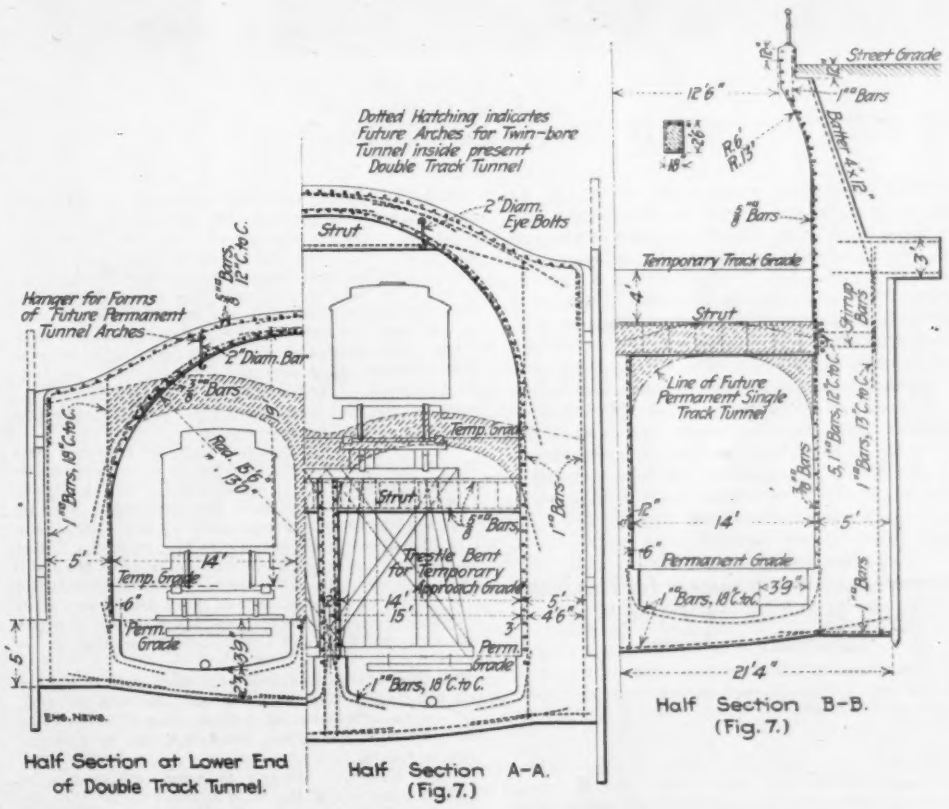

Dotted Hatching indicates Future Arches for Twin-bore Tunnel inside present Double Track Tunnel
Strut
2" Diam. Eye Bolts
Hanger for Forms of Future Permanent Tunnel Arches
2" Diam. Bar
Temp. Grade
Strut
Trestle Bent for Temporary Approach Grade
Perm. Grade
Half Section at Lower End of Double Track Tunnel.
Half Section A-A. (Fig. 7.)
Street Grade
Temporary Track Grade
Strut
Line of Future Permanent Single Track Tunnel
Permanent Grade
21'4"
Half Section B-B. (Fig. 7.)

FIG. 8. CROSS SECTIONS OF APPROACH WHERE PROVISION IS MADE FOR PERMANENT AND TEMPORARY GRADES.

### Tunnel for Water Pipes.

The city at first proposed to require the tunnel to have accommodation for the water pipes, etc., which had been laid in the footway passage of the old tunnel. Investigation showed, however, that this would involve very heavy additional cost, and might interfere with the extension of the freight tunnels of the Illinois Tunnel Co., owing to the great width of the triple tube tunnel. The plan finally adopted was to drive a tunnel of horseshoe section, 10 × 11 ft., in the bed of the river, with its crown at an elevation

of about 71 ft. below datum, or 16 ft. below the bottom of the railway tunnel. This was built by ordinary methods, without the use of air pressure, and is lined with concrete. This tunnel is about 700 ft. long, extending between shafts in South Water St. and Kinzie St., from which shafts the pipes, etc., are led to connections with the existing system.

**Engineers and Contractors.**

The work is being done for the Chicago Railways Co., on whose system the three river tunnels are located. The construction is under the direction of the Board of Supervising Engineers, which has charge of all street railway reconstruction and which prepared the plans and specifications (excepting the plans for the river section as executed). Mr. Bion J. Arnold is Chief Engineer of the Board; Mr. Geo. Weston is Assistant Chief Engineer and represents the city; Mr. John Z. Murphy, Chief Engineer of the railway, represents the company on the Board. Mr. Wm. Artingstall is Division Engineer for the Board. The contract was awarded to the M. H. McGovern Co., of Chicago, which has now associated with it J. A. Green, Charles Green and R. H. Green, of Chicago. The design of the tunnel tubes for the river section was prepared by E. C. & R. M. Shankland and J. W. Pearl, as engineers for the contractors. Mr. Max Landguth was the superintendent for the contractors, and proposed the general methods of constructing both the river section and the land tunnels. The steel work of the tubes was built by the Henry Pratt Co., of Chicago.

FIG. 9. STEEL REINFORCEMENT IN PLACE FOR THE ARCHES OF THE TWIN-TUBE APPROACH. TUNNELS BUILT IN OPEN CUT.

(In the middle are the hooked ends of the vertical rods for the center wall. The pipe projecting below the timbering is the chute for depositing the concrete.)

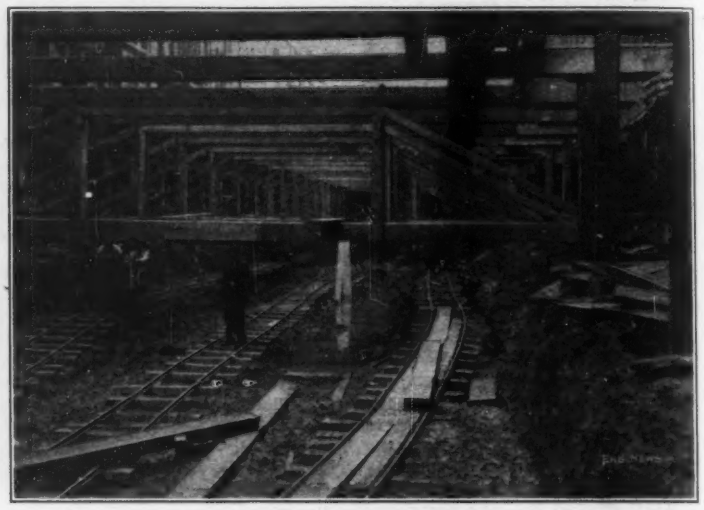


FIG. 10. TRUSSED TOP SET OF TIMBERING FOR OPEN-CUT WORK ON THE LA SALLE ST. TUNNEL; CHICAGO.

(The horizontal timbers (or chords) are butted against timber wales inside the lines of steel sheet piling. As the excavation was carried down, other horizontal and vertical timbers were placed. The trussing was used only in the top set.)

## Improvements in Machinery for Handling Earth and Rock as a Result of Experience at Panama.*

The improvements that have been made in the transportation and disposal of spoil have been of prime importance in the excavation of the Canal. Many such improvements have been made since the digging in Culebra Cut was begun, and some of them have a permanent value both for the work on the Isthmus and elsewhere.

Flat cars with one high side and the other side open are used for hauling most of the spoil from Culebra Cut. The high side, permitting of a heavier load on that side of the car than on the other, was found to be the cause of an unequal distribution of weight, and to overcome this the floor has been extended 11 ins. on the low side, making it possible to distribute the weight of the load nearer the center line of the trucks, and also enabling the unloading plows to throw the spoil farther away from the tracks when the material is ploughed off.

It was found early in the use of these cars that the unloading plow was causing a lot of damage to the high sides by running into them, in passing from one car to another. This cause of trouble and expense has been eliminated by binding the high side of the car with an iron ferrule, known as the "bull nose," which presents a beveled edge to the plow and thus steers it into position as it passes from car to car.

These cars were provided with a sheet steel apron so fastened to the end of one car that it could lap over the coupling mechanism and thus make the train continuous. The aprons were so set that the unloading plows frequently tore them off. In fact there is a record of 130 aprons having been torn from the cars in one day. The means of fastening these aprons has been so changed that now they are seldom torn off, half a dozen such accidents in a day being the average.

Trouble was also experienced in the first days of the heavy trains from the coupling breaking and the trains parting. A bridle has been devised which overcomes this difficulty, by holding the cars together in case the automatic coupler parts from any cause. By using the bridle the cars are held in their original position, even after the coupler has broken, and the parting of the compressed air line is thus obviated. Each train crew is supplied with two of these bridles for emergencies, and 1,200 of them have been made for the Canal and Panama railroad service.

These bridles are especially serviceable in the coupling between a Lidgerwood unloader reel car and its locomotive, where the pipe which carries the steam from the locomotive to the reel engine formerly broke every time a coupling gave way, subjecting any one near the break to a scalding. At one time it was difficult to persuade men to work near the coupling because of the danger from this source, but now the cars cannot part.

The machines used on the dumps have undergone most improvement. They are the unloaders, spreaders, and track shifters. They are handled by transportation men, with the grade of "qualified conductor," who have been especially trained for this service.

The unloading of flat cars is done by pulling a steel plow from one end of the train to the other by means of a cable attached to a powerful winding engine. When first used on the Canal work the plow was a skeleton with a plate wing. It was weighted down with from 7 to 12 tons of ballast in order to keep it on the bottom of the cars and prevent it from riding over the spoil. Small rock was continually working under the bottom and over the top of the plow, and, as there was no way for it to escape except by being ground out, it did constant damage to the floor and was continually catching in the aprons.

The plow has been covered with sheet steel on the top and bottom and thus the small rock has been excluded, and by an adjustment of ballast along the share, 3½ tons of weight have been found sufficient to hold the plow on the floor.

It was necessary formerly to spend several minutes in digging the end of the cable attached to the plow out of the spoil along the face. This waste of time has been eliminated by forming grommets out of worn-out cable and attaching them to the plows where they are always in plain sight, so that the unloading cable can be coupled to the grommet without any of the work of digging rock and earth away from the face.

Another waste of time was that formerly experienced in attaching the cable to the stretching frame, and loosening it after it had been stretched over the train. A slip link has been placed in the chain, which holds the cable to the stretching frame, and a blow from an iron rod opens this link, allowing the cable to fall upon the car without the train even stopping. In this chain there has been placed a soft link with a breaking strain of 1½ tons, and if anything interferes with the plow which may place an unduly heavy strain on the cable, this link will give way, thus saving the cable stretcher from being wrecked.

Not infrequently it is desirable to unload a train on a curve, and under such conditions it is almost impossible to keep the cable on the train, because under the great strain of the unloading it naturally seeks the shortest line. A block to hold the cable in place has therefore been devised. This block is fixed to a 3¾-in. chain 8 ft. long, on the other end of which is a hook that can be attached to the arch bar of the car truck. The cable runs through this block and is thus held in place.

On one day, about eight months ago, one unloader at Tabernilla unloaded 18 trains of 19 cars to a train, in all 3½ miles of cars. In August, an average of 40 cars a day was unloaded at Balboa, or 13⅓ trains to an unloader; 19 cars of 20 cu. yds. to each train.

In handling soft dirt in slides, and other material where it is necessary to uncouple cars from a train and back them alongside the shovels, the steel aprons that join the cars are thrown back, in order that the couplings may be broken. In the loading, these aprons are frequently covered with a ton or so of spoil, and when it becomes necessary to throw them back into position, so that the plow can pass over them, considerable labor is required to take the spoil off the top of the apron. All this work has been obviated by an apron thrower, which consists of a short chain with a hook on one end and a cable grip on the other. The hook is placed under the apron and the grip fixed to the moving unloading cable, and thus the apron is returned to its correct position in advance of the plow.

Fifty-one improvements have been made on the machine used to spread material on the dumps, and each one has added something to efficiency or subtracted from the time spent in operating. This spreader consists of a car on which is erected a machine with steel wings, which reach out 11½ ft. from the rails on either side and level off the material dumped from the spoil trains. Two thousand men with shovels could not do as quickly and as well the work which is done by one of these machines when it is operating at its best.

The spreader is operated by compressed air. The main reservoir in which the air is stored has been moved from its original position, parallel with the length of the car, and placed in a position where it is less in the way, while all the piping has been rearranged for pressure from this reservoir, instead of from the train air line. An operator's table, under cover, has been erected at the rear of the car, and the operator occupies an elevated position from which he can witness all the movements of the machine. Six air switches in front of him give him complete control.

When they arrived on the Isthmus these machines were so constructed that they could not clear one another on the main line of the railroad, even when the spreading wings were folded. They have been altered so that they now clear.

A wheel on the front wing, which ran along the track and frequently caught in and split expansion rails and switches, has been replaced by a shoe which rests on the rail and takes the weight off the wing without in any way interfering with the rails. Shoes have been added along the edge of the wings to take the wear, thus saving the main ploughshare. Other improvements are in minor parts, but each one has added to the efficiency of the spreader.

The system of dumping flat cars by the use of the plow necessitates the constant moving of tracks in order that the dumps may be kept in uniformly level condition. This is done by a shifter, devised for work on the Isthmus. It consists of a boom, extending from a flat car out over the track in advance of the car, and

*From the "Canal Record," Dec. 28.

tackle, by means of which the track is lifted from its bed. Another boom extending from the car at an angle with the main boom is used for pulling the track to one side or the other.

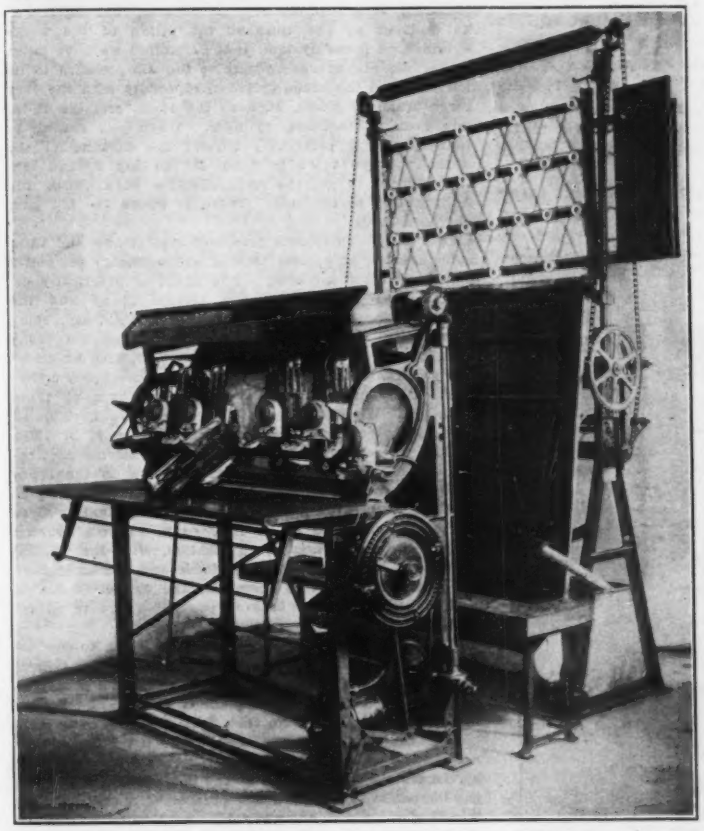
The track shifter has been so improved that track can be thrown 9 ft. from its original position in one operation, instead of only 5 ft. as formerly. A change in all the shifters is now in progress by which the engine for running the hoists will take steam from the locomotive boiler and thus make it possible to operate the track shifter more economically, because of a saving in wages and in the amount of fuel used.

An example of the work of one of these shifters was that done at Tabernilla dump about eight months ago, when 1¼ miles of track were shifted 12 ft. from the original position in 1 hour and 50 minutes.

## A White-Print Process and Continuous Printing Machine.

In the remarkable development of the use of processes for reproducing drawings or other matter from originals (on transparent paper or cloth) the blueprint process has been the most extensively used, but has the objection of producing a "negative" copy, with white lines on a dark ground. This is not only somewhat difficult for the eye to follow or comprehend, but changes and additions can only be made by the use of chemical solutions or colored pencils and inks. For typewritten work, also, the blueprint copy is hard to read and is trying to the eyes. There has been a field open, therefore, for processes reproducing the original as a "positive" copy, with dark lines (blue or brown) upon a white ground. Several such processes have been introduced, but nearly all of these are at a disadvantage in requiring two separate treatments, giving first a negative copy from which a second positive copy is made. This involves extra expense, time and trouble.

A simple white-printing process which gives a direct positive copy (with one treatment) has been developed within the past few years, and has been adopted by a number of railways and manufacturing firms requiring a large amount of work in the copying of drawings, contracts, specifications, maps, etc. It is a continuous process, the prints being made upon a roll of special sensitized paper and afterwards cut to the required size. The work is done as rapidly as blueprinting.



AUTOMATIC CONTINUOUS MACHINE FOR MAKING DIRECT WHITE-PRINTS, AND FOR WASHING AND DRYING THE PRINTS.
(The C. F. Pease Co., Chicago; Manufacturers.)

Special machines and treatment are required in the operation of this process, and a view of one of the machines is shown in the accompanying cut. A roll of the special paper is placed on a spindle underneath the printer. The sheet of paper passes across the zone lighted by the battery of electric arc lamps, and up over a roller above the printing frame. From this it passes down to the developing and fixing tanks, and then through a washer, in which it is washed by streams of water, it then rises at the back of the machine, passing in front of a gas or electric heater. At the top of the heater frame it passes again over a roller and down to the roller upon which the printed paper, dry and finished, is finally wound in a loose or open roll. It is not necessary to wait for the completion of an entire roll of paper. As soon as the operator has finished the printing required he cuts off the sensitized paper, and pastes its end to a blank strip of paper, known as the leader, which is run through the machine until one end rests in the rolling-up device and the other on the table of the printing apparatus. The machine is then ready to start again whenever required.

The tracings, or other originals, are placed right side up, and are fed in from the table. After passing the printing device they are returned directly to a receiving tray in front of the operator. The movements can be regulated as desired, and the time of development varied according to the exposure given to the print. The machine is operated by a small electric motor (shown at the base of the table frame), power being transmitted to the several rolls by bevel gears and link chains. In this view the tray for receiving the tracings is raised to allow one of the arc lamps to be swung out of the printer for cleaning and trimming. When in use, this tray forms a trough just above the table, concealing the lamps. At the right of the table is the speed regulating device, giving 60 changes of speed directly through the motor. The machine is shown equipped with an electric heater.

The prints are made on a high-grade parchment paper, which retains its original whiteness and gives sharp and clear lines. It has practically no shrinkage. The color is permanent, the print not being affected by exposure to sunlight. The lines can be erased by chemicals, and alterations can be made in special blue ink. The prints can be made in widths up to 54 ins. and of any length desired, in one piece. The equipment is automatic throughout, the paper being printed, developed, washed and dried continuously, and rolled up at the end of the dryer ready for use. Only one man is required, and the work can be done at the rate of from 50 to 75 yds. per hour. The operating and maintenance expenses are very low, especially in relation to the amount of work done.

In view of the fact that blue prints as well as white prints may be required, a combination machine is made for operating both processes. The operator can change from one to the other without stopping the machine.

For cutting the finished prints, the roll is taken to a trimming table fitted with a cutting frame on which travels a sharp blade. This blade is attached to a cord or light chain operated by a small motor, and its movement is controlled by the pressure of the operator's wrist on a lever, leaving both hands free to hold and move the paper. While the paper is being cut it is held firmly by a clamp operated by a foot lever. A fixed or revolving blade may be used. This device may be used also for cutting a number of prints at once to a uniform size.

This direct white-printing process is the invention of Mr. C. F. Pease, who is the inventor also of the developing, washing and drying machines, the motor-driven trimming table, and other apparatus used in connection with the process. The machines and auxiliary apparatus are manufactured by the C. F. Pease Co., 167 Adams St., Chicago, and this company has also a large commercial business in printing with the use of its machines.

## Laying Wood Paving With Cement-Grout Cushion Along Street Car Tracks.

A difficulty which attends the use of wood block paving, is that of adjusting and supporting it effectively at such breaks in the pavement as are caused by manholes, sewer inlets, street railway rails, etc. The greatest amount of trouble occurs at the rails, as they form a continuous break in the center of the street, where traffic is most congested. The manholes and inlets are scattered and are placed where they are subject only to an average amount of traffic. This matter has been investigated by Mr. H. G. Davis on behalf of the Chicago Street Improvement Association, and the following information is taken from a report on the investigation.

The trouble at the rails is due to the following causes: (1) vibration caused by the movements of cars, (2) leakage of water into the sand cushion by passing between the rail and the paving, (3) the heavy stress to which the paving is subjected due to concentration of traffic upon it. Under these conditions, where any block pavement (wood, brick or stone) is laid upon a sand cushion a special treatment is needed to prevent the sand from being washed or jarred out of place, and a consequent settlement of the paving. This settlement, however slight, is disastrous to any pavement, and especially so for wood block paving. As soon as blocks settle, the paving begins to get the pounding effects of heavily loaded vehicles and a rut is produced.

The vibration alone will tend to shift the sand, but when water gets into the sand the latter becomes extremely mobile and the movement is accentuated. The vibration has also a pumping effect upon the saturated sand, and may cause it to flow to the surface of the pavement. Should this saturated bed of sand become frozen, it is likely to heave to such an extent as to cause damage to the pavement. To reduce the jarring, the joint along the rail should be fitted as perfectly as possible, so that wheels of vehicles will not drop or climb in passing from the rail to the pavement.

The remedy for the shifting of the sand and consequent settlement of the paving is believed to be in the treatment of the sand cushion. About five years ago, the South Park Commission (Chicago) began using wood block paving for intersections of parkways with streets having car tracks, and laid the blocks on a cushion of cement grout instead of sand. This paving has proved successful under heavy traffic. The plan suggested, therefore, is to use this sand-cement grout instead of sand for the cushion bed between the rails and for at least 12 ins. outside the rails. This cushion will not be affected by water or vibration. This arrangement is not entirely new, and is included in the plans prepared some time ago for Chicago street-railway track construction with brick pavement (Engineering News, Nov. 3, 1910). In this case, however, the grout cushion is used only for a strip on each side of each rail.

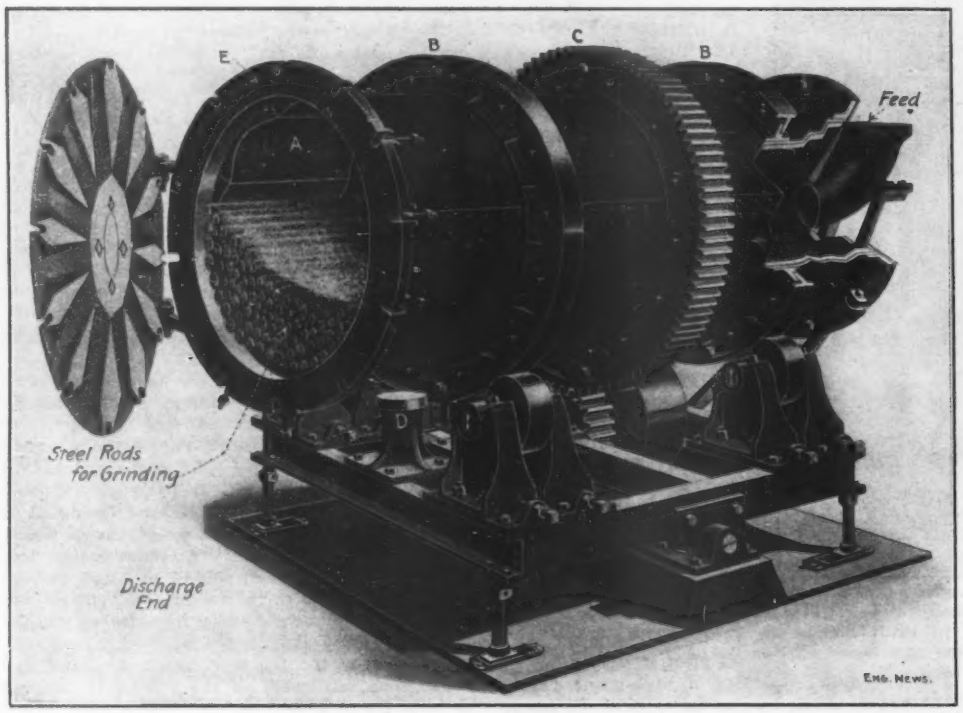
It is recommended that a dry mixture of 1 part Portland cement to 3 parts sand should be made, and spread in the same way as the ordinary sand cushion. The blocks are laid upon this and tamped. Then the paving is flushed thoroughly,

so that the water will pass through the joints and interstices and saturate the sand-cement base. It is best to keep traffic off the pavement for 24 or 48 hours, in order to give the grout time to set. It is said that this is not absolutely necessary, however, as even if the traffic is admitted immediately, the material will "cake" sufficiently to be superior to a sand cushion. The additional cost is said to be very slight. This grout cushion may be used with either wood, brick or stone block paving; it may be used also around manholes, etc., if desired.

Another difficulty experienced where wood block paving is laid between the rails is the development of transverse ruts or grooves at the tie-rods which hold the rails together. This is due to the wide joint, and it is suggested that where such rods are used, the blocks should be chamfered so as to permit of making the usual close joint. This would cause a little trouble in laying the pavement, but not enough to add materially to the cost.

## A New Type of Mill for Fine Grinding.

The "Marathon" mill which has been brought out recently for fine grinding or pulverizing is in effect a horizontal tube mill containing a number of loose steel rods 3 to 4 ins. diameter. These crush the material directly by their rolling motion, while their weight causes the particles of the material to crush and grind upon each other. A sectional view of the mill is given in the accompanying cut. The rods are nearly the full length of the mill, and beveled faces on the inside of the door at the discharge end give a slight longitudinal motion. The mill has a lining formed with longitudinal waves or wide corrugations (A); these displace any rods which work to the sides and so prevent the rods from settling together in one place. When the mill is charged and revolving, the rods have an incessantly changing movement in the body of material.




THE MARATHON MILL FOR FINE GRINDING (A TUBE MILL IN WHICH THE GRINDING IS DONE BY STEEL RODS).
(The Johnson Engineering Works, Chicago; Builders.)

The principle is very similar to that of a ball or pebble mill, but the rods are of much greater weight than pebbles, and give a much greater length of contact surfaces. The shell of the mill is of boiler plate, with two circular tracks (B) (B) riding on live rollers, and at the center is a circular driving rack (C). It can be set at an angle from the horizontal, with the discharge opening at the lower end, and in this position the end thrust is taken by a horizontal roller (D) which bears against the side of the first circular track (B). The angle is adjusted by jack screws under the corners of the bed plate. The fineness of the product is regulated by this adjustment, the material passing through more rapidly (and receiving less work) as the angle is increased. For the same reason a longer mill is used for material requiring exceptionally fine grinding. The finished product escapes through apertures between the door and the end flange of the mill (E); when the mill is erected its discharge end is enclosed in a hood or housing. This is not shown in the cut.

The machine is designed in three sizes of 24, 36 and 48 ins. diameter. For a 36-in. mill grinding cement (requiring a high degree of fineness) the length would be 9 ft. (with about 6,000 lbs. of rods); the same mill for work on ores would be about 6 ft. long, with 4,000 lbs. of rods. It is essentially a slow-speed machine making 36, 33 and 30 r.p.m. for the three sizes respectively. The grinding proceeds very rapidly, and it is necessary to keep the mill well charged, so as to have all the spaces between the rods filled with material. Under these conditions the greater part of the grinding will be done by the material itself and only a small proportion by the direct action of the rods. It is claimed that it will do more work than other machines of equivalent capacity, with less power and less wear. It will take any size of feed up to 2 ins. (being fed directly from a crusher), and is said to produce a uniform product of any desired size, with a minimum of oversize. It will work on either wet or dry grinding.

A report of a test made with the first of these mills in comparison with a pebble mill of the same size at the plant of the Gertie Mining & Milling Co., at Hill City, So. Dak., states that the former ground three times as much material through 80 mesh, over three times as much through 100 mesh, and four times as much through 200 mesh. The ore was hard quartz, and the size of feed was between 16 and 30 mesh, although in ordinary work the new mill would give better results with coarser feed.

The machine is being introduced by the Johnson Engineering Works, First National Bank Building, Chicago.

## Notes from Engineering Schools.

UNIVERSITY OF NEBRASKA.—The new Mechanical Engineering Laboratories of the College of Engineering at Lincoln, Neb., will be opened on Jan. 18, with appropriate ceremonies.

## The Control-Valve Air-Brake and the Electrically Controlled Triple-Valve.*

By F. M. NELLIS.†

The Westinghouse Air Brake Co. has found that the cars have grown so heavy that it is difficult now to make a stop in the same distance that we have been able to previously; that is, up to the time of the Central Railroad of New Jersey tests. One stop there was made in less than a thousand feet. Since then there has really been nothing done except in the way of improving the triple valve to give a higher pressure in the brake cylinder.

About a year ago a certain railroad in the country discovered in trying to make the shortest possible stop, that it required from a speed of sixty miles an hour something like 2,000 ft. in which to bring the train to a standstill. They thought that was not short enough. We thought so, too. So we have designed a new brake which we call our "P. C." equipment. That is a symbol for a passenger brake with a control valve instead of a triple valve. The triple valve has been found inadequate for passing a sufficiently large volume of air pressure to the brake cylinder quickly enough to make a stop shorter than 2,000 ft. This new brake has been designed to accomplish that. With this new brake the stopping distance was brought down from something like 2,000 ft. at sixty miles an hour to about 1,200 ft., and the principal work required in accomplishing that object was to quicken up the time of the filling of the brake cylinder. I mean by that, that heretofore we have taken rather too much time in getting the air pressure to its maximum in the brake cylinder, especially with the very large brake cylinders, such as the 16-in. and the 18-in. and even up to 20-in. cylinder. When you get up to that size it is practically beyond the capacity of the ordinary triple valve to dump air quickly enough into the cylinder to get the most effective work during the first portion of the stop. There is where the big gain has been made.

The "P. C." equipment possesses several new and valuable features, at present lacking and necessary for better passenger train operation. The brake is practically divorced into two halves, the service brake and the emergency brake, one almost entirely, I might say, being independent of the other. We have a service brake cylinder supplied with a service reservoir, also an emergency brake cylinder supplied with an emergency reservoir. A common control valve serves both of those cylinders. We have graduated release. We have quick recharge. We have high pressure emergency, or 180% braking power, while we have 90% in service application. We get no additional pressure now in the brake cylinder from the brake pipe, as we vent the brake-pipe pressure to the atmosphere. The service application gives a cylinder pressure of 86 lbs., equal to 90% braking power. In the emergency application, with the "P. C." equipment, both the service cylinder and the emergency cylinder are pulled into operation, and we get 86 lbs. in each cylinder, or 18% braking power. There is no reducing valve used.

And we are not near the end yet. Right to-day we have a steam road train running experimentally that is being electrically controlled; that is, we have a magnet valve on each triple valve cap under the car and a storage battery on the engine from which wires run to each one of the magnet valves. Thus the actuation of the magnet valves is simultaneous, regardless of the length of the train. Just as soon as the engineer's brake valve handle reaches the emergency position it makes an electric contact which energizes all the magnet valves on the triple valve caps, and these magnets vent the pressure right from the triple valve caps; that is, immediately from the face of the triple valve to the atmosphere, and every triple valve goes into emergency instantaneously. That saves something like a second during the propogation of quick action through the ordinary train.

A COAL DUST EXPLOSION at the plant of the Portland Cement Co., six miles east of Florence, Colo., Jan. 3, caused the death of two workmen and the injury of seven others. The accident occurred in the second story of the coal pulverizing department, which was being swept out.

A REAR COLLISION in the Northern Pacific Ry. yards at Cheney, Wash., Jan. 4, caused the death of six men. An eastbound Chicago, Burlington & Quincy passenger train was just about to take a siding when it was struck by the "North Coast Limited," running almost at full speed. The three rear coaches of the Burlington train were demolished. The accident is ascribed to an unexplained delay in getting the Burlington train onto the siding.

A STREET CAR AIR-BRAKE TANK burst, Jan. 5, at Pittsburg, Pa. Three pedestrians near the car were severely injured by flying fragments of the tank and brake mechanism.

*Extract from a discussion before the New England Railroad Club, at Boston, Mass., Dec. 13, 1910.

†New England representative, Westinghouse Air Brake Co. and Westinghouse Traction Brake Co., 53 State St., Boston, Mass.

A COAL MINE EXPLOSION, Jan. 3, at Sydney, N. S., wrecked the No. 3 mine of the Nova Scotia Steel & Coal Co. The accident occurred at about 4 a. m., just after eight men, all of whom were killed, had entered the mine. The mine had been closed Jan. 1 and 2, in observance of New Year's Day, and the fans had been stopped during that time. The explosion is attributed to an accumulation of gas in the mine while the fans were idle.

TRESPASSING ON PENNSYLVANIA R. R. property, according to a bulletin recently issued by that company, has caused the deaths of 7,996 people—approximately two a day—since Jan. 1, 1900. In the same time 7,838 people have been injured as a result of trespassing. The maximum number killed in any one year was in 1907, when 916 trespassers lost their lives in this way. Through the efforts of the railroad's officers and employes, the number of trespassers killed in 1908 was reduced to 743. In 1909 the number killed was reduced to 633, and in 1910 there were 585 deaths from trespassing on the Pennsylvania R. R. property. This is less than in any one of the previous ten years.

THE COMMISSION PLAN OF CITY GOVERNMENT for Springfield, Ill., has just been adopted by popular vote.

A NEW RECORDING THERMOMETER for the lower ranges of temperature has been recently developed by the Bristol Co. of Waterbury, Conn. The recording thermometers previously constructed by this company, and depending for their operation on the expansion of a liquid, a vapor or a gas, have been useful only for higher temperatures up to 800° F. The principal feature of the new thermometer is a compensating device applied to the spiral pressure tube, through which the thermometer is made to give correct readings at the point where the sensitive bulb is placed, regardless of changes in temperature of the recording instrument itself. The compensating attachment affects the spiral tube only, and no effort is made to compensate for changes of temperature in the capillary tube connecting the sensitive bulb with the pressure coil. The volume of gas in the bulb, however, is very large in comparison with the volume contained in the tube, so that the error due to changes in the tube temperature is negligible. The new thermometer is applicable for recording atmospheric temperatures of water, temperatures of brine in refrigerating systems and other temperatures below 212° F.

THE SERIOUS ACCIDENTS ON ELECTRIC RAILways during the past year, although nearly all outside of New York State, have aroused the New York Public Service Commission, Second District, to take action aimed at the prevention of future accidents of this sort on the interurban electric lines of the state. A resolution has been adopted calling a conference at Syracuse, N. Y., for Jan. 19, 1911, of general managers, division superintendents, chief train despatchers and master mechanics of the interurban electric lines under the jurisdiction of the Commission. Questions affecting the safety of operation of these railways will be discussed and papers will be presented as follows: "Methods of Employment, Instruction and Discipline of Motormen and Conductors on Interurban Roads," J. K. Choate, General Manager, Otsego & Herkimer R. R.; "Collisions on Interurban Roads and Their Causes," E. F. Peck, General Manager, Schenectady Ry.; "Train Despatching on Interurban Roads," C. E. Lewis, Chief Train Dispatcher, New York State Rys.; "Block Signals on Interurban Roads," W. K. Howe, Chief Engineer, General Railway Signal Co.

THE PARTIAL FAILURE OF A STEEL COFFERDAM at Chicago recently is of interest in connection with the editorial discussion on the design of the cofferdam to be used in raising the "Maine," in our issue of Dec. 29. The cofferdam was on the south side of the Chicago River, across the head of La Salle St. It was built to enable tunneling to be commenced on the south approach of the new La Salle St. tunnel without waiting for the sinking in place of the steel tubes which will form the river section of the tunnel. The cofferdam was 50 ft. long, and was composed of two lines of United States interlocking steel sheet piling 8 ft. apart and connected by 1½-in. tie-rods spaced 6 ft. apart vertically and horizontally. The nuts had cast-iron washers bearing against 3-in. oak waling timbers. The cofferdam extended between two rows of Friestedt steel sheet piling at right angles to it; its ends rested in recesses formed by these latter piles, but were not fastened to or interlocked with the latter.

When the clay filling in the 8-ft. space had been practically completed the slip occurred; the piling bulged outward under the pressure and some of the clay escaped at the ends of the cofferdam. The reason which is attributed for this slip is that the diver who put in the tie rods failed to screw up the nuts properly. We are informed that some of the rods pulled out, and that some of the waling pieces were broken apart by the pressure. It appears that the piles did not unlock, and did not break way from their hold in the river bed; but that the line of piling bulged out of shape. The piles were 45 ft. long, and had a penetration of about 15 ft. in the clay. The dredging for a trench on the river side of the cofferdam (to receive the tunnel tubes) gave a depth of about 30 ft. of water against the piling.

After the slip, a row of round timber piles was driven on the river side of the cofferdam. Steel I-beams were placed against these as waling pieces, and were anchored back to deadmen sunk in the street, some distance from the cofferdam.

THE LARGE CONCRETE ARCH BRIDGE proposed to carry the New York State Barge Canal across the gorge at Medina, N. Y. (Engineering News, March 10, 1910, p. 274), will probably not be built. This arch was to have a clear span of 285 ft., a rise of 53 ft. 5 ins. and a width of 129 ft., making it the fourth longest and by far the widest masonry arch in the world, but it was in its loading that it surpassed all existing structures of its type, for it was designed to carry a prism of water 13 ft. 2 ins. deep, a load of 825 lbs. per sq. ft. A number of model arches were made and tested under load to determine the behavior of such an arch and to assist the designers, and the results of these tests have been published in this journal. It now appears, however, that the recently retired State Engineer, Mr. Frank M. Williams, did not care to authorize the construction of the mammoth arch. His recently published final report contains the following paragraph:

> I have at hand plans prepared for the construction of the section of canal at Medina, which is not yet under contract, but inasmuch as this involves the building of a concrete arch of dimensions hitherto not equalled in this country, I have refrained from placing this section under contract, because I believe that in so unique a plan the engineer responsible for the design should also have the opportunity to carry out the construction. Therefore I have left this matter to be determined by my successor.

It is of course possible that the present State Engineer, Mr. John A. Bensel, may conclude to proceed with this construction, but the length of time which would be needed for him to satisfy himself as to the design and the comparative simplicity of a culvert and fill crossing at Medina leaves the latter solution of the problem to be expected.

THE MAIN POWER STATION of the Minneapolis General Electric Co. was wrecked by fire on Jan. 6. It was first reported that, at 6.35 a. m., something blew out on the switchboard and a larger explosion followed. An authentic despatch, however, states that there is no evidence of an explosion and that the origin of the fire is unknown. The 13,000-volt cables, carrying power into the station from the Taylor's Falls power plant of this company, were short-circuited, but it is not known whether before or during the fire. The apparatus damaged had an aggregate capacity of 12,000 HP. It is believed that 2,500 HP. of water turbines and generators was little damaged and that the boilers and engine flywheels are intact. The plant cost about $750,000, the insurance was on $500,000, and the salvage is unknown.

The city was left almost without electric current supply and many manufacturing concerns, printing houses, etc., had to suspend operation temporarily. The street cars, however, were not interfered with as the traction company generated its own power. Power from the Taylor's Falls plant was distributed through this plant to several substations, and after the fire temporary connections were made to these so that on the following day the lighting and power service was normal except for 1,000 street arcs and a few small power circuits.

THE SELDEN AUTOMOBILE PATENT which was sustained by Judge Hough of the U. S. Circuit Court in an opinion delivered on Sept. 8, 1909, was declared invalid by the U. S. Circuit Court of Appeals, Second Circuit, Judges Lacombe, Ward and Noyes, in an opinion handed down on Jan. 9. The principal claim of the Selden patent on which the inventor chiefly relied reads as follows:

> The combination with a road-locomotive, provided with steering running gear, including a propelling wheel and steering mechanism, of a liquid hydrocarbon gas-engine of the compression type, comprising one or more power cylinders, a suitable liquid-fuel receptacle, a power shaft connected with and arranged to run faster than the propelling wheel, and an intermediate clutch or disconnecting device and a suitable carriage body adapted to the convenience of persons or goods, substantially as described.

The owners of the Selden patent have held that under this claim any road vehicle propelled by an internal combustion engine using liquid fuel was an infringement of their patent. The majority of the manufacturers of automobiles have recognized the validity of the patent by taking out licenses under it. Others, however, have refused to pay license fees and the suit against them for infringement has been in progress for years.

The Court of Appeals finds, in analyzing the claim above quoted, that of the elements which it contained, the carriage and its parts and the driving mechanism and its parts were not novel. The engine element is therefore the main feature of the claim. It was shown, in the testimony, however, that previous inventors had combined gas engines with road vehicles and the Selden patent must be limited therefore to the "engine of the compression type" which the claim refers to. By this term Selden meant, not the now familiar Otto type of engine in which the mixed gas and air is compressed before explosion, but an engine of the now defunct Brayton type, a two-cycle engine operating at constant pressure, and requiring a separate compressing cylinder. But the Brayton engine had been applied to road vehicles before the Selden application was filed. All that Selden could rightfully claim, therefore, was the use with road vehicles of the Brayton type of engine with certain improvements which Selden showed in his patent. These improvements, however, did not suffice to make the Selden automobile a successful working machine. In fact, Selden's patent was a paper one only. He never actually built and operated the invention which his patent described.

The Court in its conclusion says:

> Selden undoubtedly appreciated the possibilities of the motor vehicle at a time when his ideas were regarded as chimerical. Had he been able to see far enough he might have taken out a patent as far-reaching as the Circuit Court held this one was. But like many another inventor, while he had a conception of the object to be accomplished, he went in the wrong direction. The Brayton engine was the leading engine at the time and his attention was naturally drawn to its supposed advantages. He chose that type. In the light of events we can see that had he appreciated the superiority of the Otto engine and adapted that type for his combination, his patent would cover the modern automobile. He did not do so. He made the wrong choice and we cannot, by placing any forced construction upon the patent or by straining the doctrine of equivalents, make another choice for him at the expense of these defendants who neither legally nor morally owe him anything.

DIRECT-ACTING EXPLOSION PUMPS.—The Humphrey Gas Pump Co. has been organized to own and control patents, improvements and inventions for internal-combustion direct-acting pumps and elastic-fluid compressors, etc., in the United States. The particular and immediate object is to introduce and develop, in this country, direct-acting explosion pumps of the Humphrey and Smythe types, described in Engineering News, Dec. 2, 1909, and May 19, 1910. Licenses to manufacture and use such apparatus will be sold to reliable firms.

It will be remembered that in these designs an oscillating body of water serves as the piston of an internal-combustion cylinder. There are no piston rods, flywheels, crank-shafts, glands, etc., and the gas and water valves become very simple. Little accurate machine work is needed which, together with the higher efficiency, makes it possible to build these pumps at about half the cost of engine-driven apparatus of the same capacity. These were first developed as simple drowned-suction, medium-lift (up to 40 ft) types, working on a four-stroke cycle, but they have been found easy of adaptation as suction lift, high-head, double-barrel, and two-cycle apparatus. Their use has even been proposed as peak-load auxiliary power in hydro-electric installations.

EXTENSIVE ROAD IMPROVEMENTS IN CALIFORnia are projected by the state, and still others are already under way or are projected by a number of counties. On Nov. 8, 1910, the voters of the state ratified a recent legislative act providing for a bond issue of $18,000,000 to construct a system of state highways designed to connect the various county seats of California. The roads so built will be under the jurisdiction of the state. Money for maintenance will be appropriated separately. The entire bond issue of $18,000,000 will be used exclusively for right-of-way and construction. The funds will be available about July 1, 1911. Sole responsibility for constructing and maintaining these state roads will be vested in the Department of Engineering of the State of California, which is headed by Mr. Nathaniel Ellery, M. Am. Soc. C. E., State Engineer. Associated with Mr. Ellery on an Advisory Board to the Department of Engineering are Messrs. J. N. Gillett, Governor; W. V. Stafford, President of the State Harbor Commission, and F. W. Hatch, General Superintendent of State Hospitals. Besides the large bond issue authorized by the state, bond issues for road improvement have been authorized by various counties as follows: Los Angeles Co., $3,500,000; San Diego Co., $1,250,000; San Joaquin Co., $1,890,000, and Sacramento Co., $660,000; total, $7,300,000. A dozen other counties of the state are reported to be ready to issue bonds as soon as the layout of the state system has been made. The foregoing information has been supplied us by Mr. Ellery, at our request.

TWO 20,400-HP. HYDRAULIC TURBINES are being built by the Allis-Chalmers Co., of Milwaukee, for the White River hydro-electric plant of the Pacific Coast Power Co. This development is being carried on about 20 miles east of Tacoma, Wash. The White River, from which the water is diverted, is fed by the glaciers of Mt. Ranier, and it receives its name from the fine, white silt which is carried. The water is to be diverted into a settling pond in which the silt may be deposited. The main storage reservoir is designed to hold sufficient water for three or four months continuous operation, without receiving water from the White River. This storage reservoir is made up of several existing lakes which are to be interconnected and dammed, and whose banks are to be strengthened. From the storage reservoir the water is to be carried through a 300-ft. tunnel

and through 2,200-ft. steel pipe lines. The power-house will be approximately 373 ft. long and 70 ft. wide. About 46 ft. of the width is to be used for six generating units, which are to be placed with their shafts in line. The other side of the building, 26 ft. wide, will be used for exciter units, transformer rooms, etc. At first, only two generating units will be installed, room being left for four. Each turbine will develop the rated capacity of 20,400 HP. under a head of 480 ft. Each unit will be direct connected to a 60-cycle, three-phase, 6,000-volt generator driving it at 360 r. p. m. The turbine runner is to be a high-pressure Francis type with horizontal shaft. A cast-steel runner will receive the water from a spiral casing, divide it into two lines of flow, and the discharge from the wheel will be by two quarter turns to separate draft tubes. The flow of water to the turbine will be controlled by cast-steel butterfly valves. These valves will be something over 7 ft. in diameter, and are said to be the largest of this type ever designed. The governors for these turbines will be of a standard, oil-pressure type, designed for close regulating. Separate governors will be supplied for each unit, but there will be a central oil-pressure system. This plant will have to regulate the supply of energy to the whole system of this company so that proper regulation of each turbine becomes of added importance. There is also a necessity of conserving the storage supply of water so far as possible. To this end, pressure regulators will be installed on each turbine. The Stone & Webster Engineering Corporation is acting as consulting engineers for the Pacific Coast Power Co.

## Personals.

Col. R. F. Rodman has resigned from the position of Engineer of the State Board of Public Roads of Rhode Island, to give his attention to private business.

Mr. J. Norman Jensen, formerly Designing Engineer for the Corrugated Bar Co., of St. Louis, Mo., has been appointed Architectural Engineer, Department of Public Buildings, Chicago, Ill.

Mr. E. K. Cortright, Jun. Am. Soc. C. E., has severed his connection with the Water Board of Reading, Pa., to accept the position of Superintendent of the Kaolin Mining Co., at McIntyre, Wilkinson Co., Ga.

Mr. Maurice Deutsch, formerly with the Foundation Co., of New York City, is now associated with Mr. Henry Opdycke, Civil Engineer, at 30 Church St., New York. Mr. Deutsch will specialize in foundation work.

Mr. F. P. Gutelius, Superintendent of the Lake Superior Division of the Canadian Pacific Ry. at North Bay, Ont., has been promoted to be General Superintendent of Transportation for the company at Montreal.

Mr. William E. Corey has resigned as President of the United States Steel Corporation. Mr. James A. Farrel, President of the United States Steel Products Co., has been nominated by the finance committee to succeed Mr. Corey.

Mr. Otto N. Mueller, Jun. Am. Soc. M. E., formerly Chief Engineer of the Noelke-Richards Iron Works, of Indianapolis, Ind., and Mr. Kurt Vonnegut have become members of the firm of Vonnegut & Bohn, Architects, of Indianapolis.

Mr. Reginald E. Hore, M. Am. Inst. M. E., formerly an Instructor at the Michigan College of Mines, has been appointed Assistant State Geologist of Michigan and is in charge of the Houghton office of the State Geological Survey.

Mr. Grant B. Shipley, Assoc. Am. Soc. M. E., formerly Engineer of the Mining and Timber Preserving Machinery Department of the Allis-Chalmers Co., of Milwaukee, Wis., has been elected President of the Pittsburg Wood Preserving Co., of Pittsburg, Pa.

Mr. John MacVicar, Superintendent of Streets and Public Improvements of Des Moines, Iowa, has been selected for Commissioner-General of the International Municipal Congress and Exposition, to be held in Chicago, Ill., Sept. 18-30, 1911.

Mr. Ernest F. Hartmann, Assoc. M. Am. Soc. C. E., Mr. Arthur L. Dean and Mr. John Martin Schreiber, M. Am. Soc. C. E., have formed the firm of Hartmann, Dean & Schreiber, Consulting Wood Preserving Engineers, with offices at 182 Franklyn St., New York City.

## Obituary.

William H. Martin, an aged civil and mining engineer, of San Francisco, Cal., died on Dec. 29. He was 78 years old and came to California in 1877. He took part in building the old Powell street railway.

George A. Clough, formerly City Architect of Boston, Mass., and designer of the County Court House, the English High School, and the impressive Gate of Heaven Church, South Boston, and of many other notable public buildings, died on Dec. 30, in Brookline, Mass., at the age of 67 years.

Sir John Aird, head of the well-known firm of John Aird & Sons, contractors, died in London on Jan. 6. He was born on Dec. 3, 1833. From 1887 to 1905, he was a Member of Parliament representing North Paddington. He was chiefly famous for his work in the construction of the Assuan Dam, across the River Nile in Egypt, for which his firm was the contractor.

Almon D. Hodges, M. Am. Inst. M. E., who died at Roxbury, Mass., on Nov. 7, was a graduate of Harvard University and well known to engineers on the Pacific Coast. From 1869 to 1871 he was Editor of the "Mining and Scientific Press" of San Francisco, Cal. During his later years he had carried on a consulting practice in Boston, Mass., but was a frequent visitor in San Francisco.

George W. Lee, Assoc. M. Am. Soc. C. E., Chief Engineer of the Sundstrom & Stratton Co., Contractors, of New York City, died at his home in New Rochelle, N. Y., on Jan. 6. He was born in Winsted, Conn., and was 36 years old. For the past ten years he had been with this company and had charge of much important work, especially in the improvements, for which his company was contractor, made during the last few years on the New York Central & Hudson River R. R., with which road Mr. Lee was formerly connected. Mr. Lee was a contributor to Engineering News and his articles on railway construction published in 1903, '04 and '05 will doubtless be recalled by many readers. He leaves a wife and two young children.

Leonard H. Eicholtz, a prominent citizen of Denver, Colo., and a one time engineer, died at his home in that city on Jan. 3, at the age of 84 years. He was born in Lancaster, Pa., and educated at the Moravian Academy at Lititz, as a civil engineer. In 1852, he was employed as a member of the engineering corps of the Pennsylvania R. R. At the outbreak of the Civil War he volunteered his services to the Government and served with honor as an assistant engineer of military railways in the department of the Mississippi under Gen. Sherman. In 1868 he went to Colorado and was employed by the Union Pacific Ry. as a superintendent of bridge building. He later became Superintendent of Construction and Chief Engineer of the Denver Division from Cheyenne to Denver. Soon after the completion of this road he settled in Denver and conducted a general brokerage business. He was one of the incorporators and Chief Engineer of the Denver & So. Park Ry., now part of the Union Pacific system.

Charles Hill Morgan, Past President of the American Society of Mechanical Engineers, died at his home in Worcester, Mass., on Jan. 10. He was born in Rochester, N. Y., on Jan. 8, 1831, but during his childhood his parents moved to Clinton, Mass., where, at the age of 12 years, he began working in a factory. By diligent study evenings, after 12 hours' work in the shop, he made himself capable, at the age of 21 years, of being placed in charge of the Clinton mills dye-house. He early became identified with the iron and steel industry of Worcester, and in 1864 became general superintendent of the Washburn & Moen Co., now a subsidiary company of the American Steel & Wire Co. He was also President of the Morgan Spring Co. and the Morgan Construction Co., both of Worcester. For 40 years he had been a trustee of the Worcester Polytechnic Institute of which he was one of the founders.

Mr. Morgan was also a member of the American Institute of Mining Engineers, the Iron and Steel Institute of Great Britain, and an honorary member of the Societé des Ingénieurs Civils de France. He was a public spirited citizen and a benefactor of his home city in many ways. A bographical sketch and portrait of Mr. Morgan will be found in Engineering News of Jan. 18, 1900.

## Engineering Societies.

COMING MEETINGS.

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 17. Annual meeting at Pittsburg, Pa. Secy., Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 17-19. Annual convention at San Francisco, Cal. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 18-19. Annual meeting at New York City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Jan. 20. Annual meeting at New York City. Secy., P. S. Millar, 29 West 39th St., New York City.

KANSAS ENGINEERING SOCIETY.
Jan. 20-21. Annual meeting at Topeka, Kan. Secy., W. S. Gearhart, Kansas State Agricultural College, Manhattan, Kan.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 24-26. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

OHIO ENGINEERING SOCIETY.
Jan. 24-26. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 24-27. Annual meeting at Winnipeg, Man. Secy., C. H. McLeod, 413 Dorchester St., Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 25-27. Annual meeting at East St. Louis, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 6-11. Annual convention at Louisville, Ky. Secy., T. A. Randall, Indianapolis, Ind.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 15. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, East Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 15-17. Annual meeting at Des Moines, Iowa. Secy., S. M. Woodward, Iowa City, Iowa.

CANADIAN MINING INSTITUTE.
March 1-3. Annual meeting at Quebec, Que. Secy., H. Mortimer Lamb, Windsor Hotel, Montreal, Que.

KANSAS STATE GOOD ROADS ASSOCIATION.—The annual meeting will be held at Wichita, Kan., Jan. 17-18. The President is Mr. H. W. McAfee, of Topeka, and the Secretary, Mr. W. S. Gearhart, of Manhattan, Kan.

RAILWAY SIGNAL ASSOCIATION.—The first "stated" meeting of the year will be held at Chicago, Ill., March 20. The second stated meeting will be held in New York City, June 13. The annual meeting is scheduled for Oct. 10 at Colorado Springs, Colo. The Secretary is Mr. C. C. Rosenberg, Bethlehem, Pa.

ORGANIZATION OF CITY OFFICIALS FOR STANDARDIZING PAVING SPECIFICATIONS.—The second annual convention, Jan. 9-14, in New York City, is being held at the Engineering Societies Bldg., 29 West 39th St., instead of at the Astor Hotel as announced in our issue of Dec. 22. The general meetings will be open to anyone interested in paving.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The sole business session of the 58th annual meeting in New York City will be held on the morning of Jan. 18, when annual reports will be presented, officers elected and a proposed amendment to the Constitution will be presented for action. Progress reports will be presented for discussion by the special committees on Steel Columns and Struts and on Bituminous Materials for Road Construction.

On the afternoon of Jan. 18, excursions will be made to the plant of the Keuffel & Esser Co., in Hoboken, and to the Brooklyn Navy Yard. An excursion to the works of the Bethlehem Steel Co., at Bethlehem, Pa., will occupy the morning and afternoon of Jan. 19. The evenings will be taken up by the President's reception, Jan. 18, and an informal smoker, Jan. 19.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—The eighth annual banquet of this society was held at the Hotel Savoy on Saturday evening, Jan. 7. After substantial refreshments had been enjoyed, intermixed with music, partly by a quartet of members and partly by the entire company, a number of toasts were responded to. Hon. J. P. Mitchel, President of the Board of Aldermen, made a number of complimentary remarks concerning New York City's engineering staff and then discussed the subway extension problem, which the city is now facing. Other speakers representing the city government were Borough Presidents McAneny and Miller.

Mr. Charles Warren Hunt, Secretary of the American Society of Civil Engineers, responded to the toast "Engineering." He described the essentials of success in engineering as Knowledge, Industry and Tact; these three; but the greatest of these was Tact. He then qualified knowledge as technical knowledge, but in a broader sense than it could be acquired in technical schools.

Referring then to Tact, Mr. Hunt asked his hearers if they really knew what Tact meant; he had thought that he did, but to be sure of this he had taken this definition from the Century Dictionary: "Tact = Mental perception; especially, fine perception; intuitive sense of what is true or proper; fineness or discernment as to action or conduct, especially a fine sense of how to avoid giving offense; ability to do or say what is best for the intended effect; adroitness; cleverness; address."

Mr. Hunt then humorously added that tact also meant the ability to extract large fees,—in support of which he further quoted from the dictionary that tact meant "touch." He added, however,, that in this sense the engineering profession possessed much less tact than the other so-called learned professions.

Following Mr. Hunt, Hon. W. Bourke Cockran spoke on the growth of modern cities, with particular reference to New York, past, present, and what its municipal engineers were going to make it in the future. The last two speakers were Mr. John J. Murphy and Mr. Louis K. Rourke.

Many of the songs were composed for the occasion and were lustily sung by the entire company. This verse is taken from one of the most popular, entitled the "Municipal Engineers"; tune Heidelburg-Stein song:

Dwellings were once a question great,
Brooklyn was far away;
When you went to the Bronx in the early dawn,
You had to come back the next day.
But tunnels have brought Long Island near,
With only a chute between;
While through the subway, the College Heights
Shake hands with Bowling Green.
CHORUS.
Here's to the men who built the town,
Long may they live and reign;
Kings of the works that made us great,
Lords of the land and main.
Here's to New York and all she holds;
Here's to her financiers;
And here's to the jolliest crowd she knows
Her Municipal Engineers.